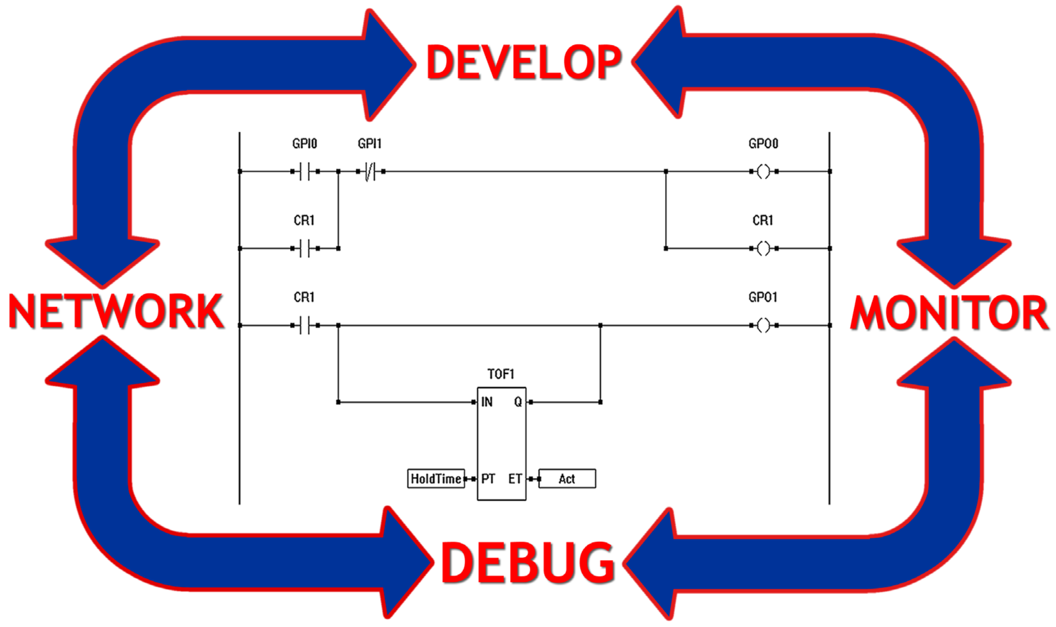
USER MANUAL

P-Series Standard Edition

EZ LADDER

TOOLKIT

ONE TOOLKIT FOR MULTIPLE SOLUTIONS



Programming Manual for all P-Series PLC on a Chip™ Based Products

Divelbiss CORPORATION

Release Version 1.07
For EZ LADDER V1.1.1.0

Table of Contents

CHAPTER 1

Getting Started

This chapter provides detailed information for getting started using the P-Series EZ LAD-DER Toolkit. Included in this section are installation instructions, activating EZ LADDER Toolkit and instructions on how information in this manual is presented.

Chapter Contents

What's New or Changed in V1.1.1.0

Updated release of this manual for EZ LADDER Toolkit V1.1.1.0 (EZ LADDER for the **P-Series PLC on a Chip™** based product line). For M-Series based **PLC on a Chip™** products, refer to the M-Series EZ LADDER Toolkit User Manual.

New Networking: J1939 & NMEA 2000
With this version, J1939 is supported on all P-Series PLC on a Chip targets. Additionally, NMEA 2000 is also supported. Refer to Chapter 14.

New Hardware Target: VB-2XXX
New Model Versatile Base (2X Series) based on P-Series PLC on a Chip™. 12 Inputs, 8 Outputs, CAN Port, 2 Serial Ports, 7 Analog Inputs, 1 Analog Output, Ethernet Port and supports Display / Keypad HMI. Expandable with additional I/O, Thermocouple inputs and VBDSP HMI board.

Update to Hardware Target: ICM-BB-P13-XX
Added expansion option to ICM-BB-P13-XX Bear Bones controllers (P-Series) for ICM-PUI-01 programmmble user interface. Adds direct control of all on-board ICM-PUI-01 I/O to be controlled directly from ladder diagram.

Updated Structured Text Functions
Listed are some additional ST Functions and Features added for the P-Series PLC on a Chip based targets in this version. See Chapter 26.
- EZ_LcdClear (Clear LCD display using Structured Text)
- EZLcdInit (Control LCD Initialization using Structured Text)
- EZ_LcdWrite (Write/Display data on LCD Display using Structured Text

Manual Corrections
Listed are some manual corrections for this release.
- TimerCounter function block (Timer/Counters) now uses a 96Mhz reference clock (for measuring frequency or period.
- Typographical errors.

How to Use this Manual

In this manual, the following conventions are used to distinguish elements of text:

BOLD	Denotes labeling, commands, and literal portions of syntax that must appear exactly as shown.
Italic	*Used for variables and placeholders that represent the type of text to be entered by the user.*
SMALL CAPS	Used to show key sequences or actual buttons, such as OK, where the user clicks the OK button.

In addition, the following symbols appear periodically appear in the left margin to call the readers attention to specific details in the text:

🚫	Warns the reader of a potential danger or hazard that is associated with certain actions.
💡	Appears when the text contains a tip that is especially helpful.
❗	Indicates that the text contains information to which the reader should pay particularly close attention.

This manual is divided into Chapters that are organized to promote a step by step progression of using the EZ LADDER Toolkit from installation to troubleshooting. Each chapter contains specific information that is relevant to understanding how to use the EZ LADDER Toolkit.

❗ EZ LADDER Toolkit is a single program that supports both the M-Series and P-Series PLC on a Chip^{TM} based targets. While all hardware targets are available, this manual's focus is on the P-Series based targets and their supported features in relation to programming and EZ LADDER Toolkit. For M-Series based targets, the M-Series EZ LADDER Toolkit User Manual should be used. Only the correct manual for the hardware based (P-Series or M-Series) should be used as there are distinct differences in configuring targets and features and functions supported between the two.

Installing the EZ LADDER Toolkit

To install EZ LADDER Toolkit on your computer, follow the following steps. Once EZ LADDER Toolkit is installed, it must be activated before it may be used with actual hardware targets.

EZ LADDER Toolkit supports Windows XP, Vista, Vista 64-bit, Windows 7, Windows 7 64-bit. Beginning with this release of EZ LADDER Toolkit, Windows 2000 and earlier versions are no longer supported.

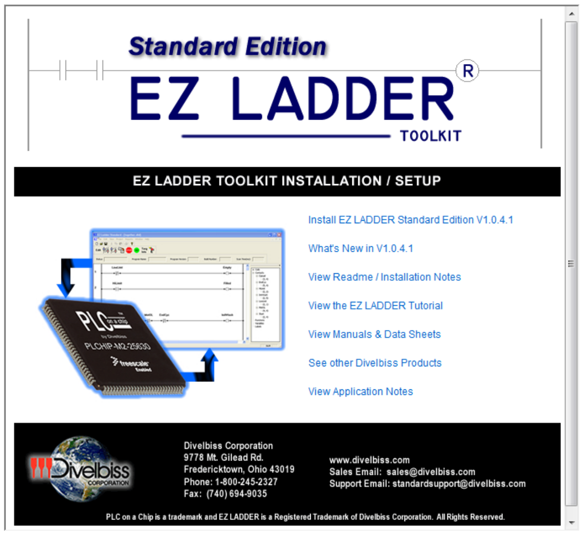
Windows Administrator Rights are required for proper installation. The EZ LADDER directory security is dependent on local / network security settings and may be set for user Read/Execute only. To allow the user to be able to write to this directory, an Administrator must change the permissions accordingly.

Windows Administrator Rights are required to install / register / activate EZ LADDER. Installing EZ LADDER Toolkit without Administrator Permissions will cause EZ LADDER Toolkit not install and not operate correctly.

1. Copy the Serial Number printed on the face of the EZ LADDER Toolkit CD to a piece of paper. You will need this serial number during installation.

2. Insert the EZ LADDER Toolkit CD into your CD drive. If you have Active Content Enabled for your CD Drive, a Menu will appear. Click the **INSTALL EZ LADDER STANDARD EDITION V X.X.X.X** to run the EZ LADDER Toolkit setup.

   If this screen does not appear. Click the **START** button and choose **RUN.** Browse to the CD Drive, the EZ LADDER directory and then the Vx.x.x.x directory. Select *Setup.exe* and click ok and ok to run the installer.

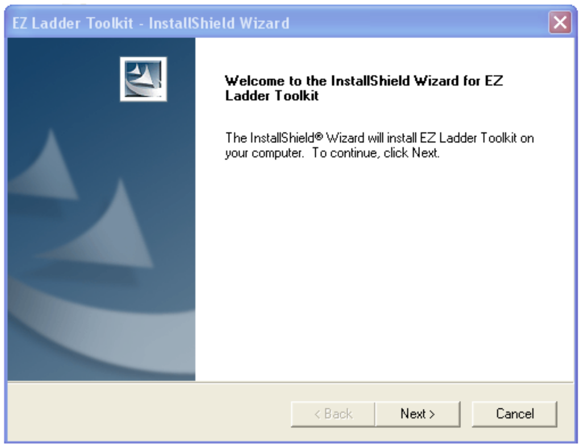

Standard Edition
EZ LADDER®
TOOLKIT
EZ LADDER TOOLKIT INSTALLATION / SETUP
Install EZ LADDER Standard Edition V1.0.4.1
What's New in V1.0.4.1
View Readme / Installation Notes
View the EZ LADDER Tutorial
View Manuals & Data Sheets
See other Divelbiss Products
View Application Notes
Divelbiss CORPORATION

Divelbiss Corporation
9778 Mt. Gilead Rd.
Fredericktown, Ohio 43019
Phone: 1-800-245-2327
Fax: (740) 694-9035

www.divelbiss.com
Sales Email: sales@divelbiss.com
Support Email: standardsupport@divelbiss.com

PLC on a Chip is a trademark and EZ LADDER is a Registered Trademark of Divelbiss Corporation. All Rights Reserved.

3. The EZ LADDER Toolkit Installation Wizard will open. Click **NEXT.**

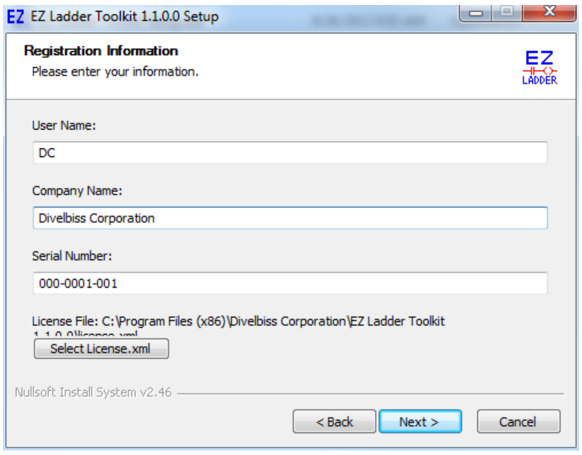


Welcome to the InstallShield Wizard for EZ Ladder Toolkit

The InstallShield® Wizard will install EZ Ladder Toolkit on your computer. To continue, click Next.

4. Complete the Name, Organization fields and enter the Serial Number. Do not click the **SELECT LICENSE XML** button. This button should only be used under Divelbiss personnel supervision. Click **NEXT**.

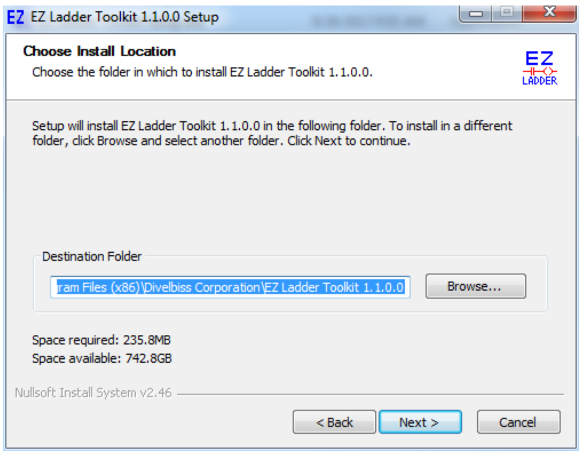
The serial number entered is used during activation. If the serial number is not correct, you will not be able to activate your EZ LADDER Toolkit later.


EZ Ladder Toolkit 1.1.0.0 Setup

Registration Information
Please enter your information.

User Name: DC
Company Name: Divelbiss Corporation
Serial Number: 000-0001-001
License File: C:\Program Files (x86)\Divelbiss Corporation\EZ Ladder Toolkit 1.1.0.0\license.xml

5. Use the default location for installing the EZ LADDER Toolkit or browse and select a different location. Click **NEXT**.


EZ Ladder Toolkit 1.1.0.0 Setup

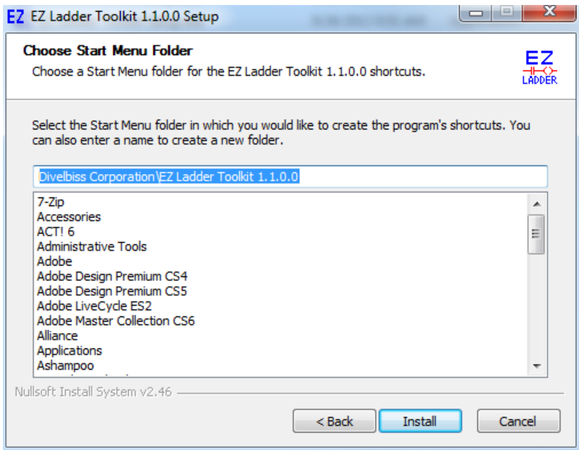
Choose Install Location
Choose the folder in which to install EZ Ladder Toolkit 1.1.0.0.

Setup will install EZ Ladder Toolkit 1.1.0.0 in the following folder. To install in a different folder, click Browse and select another folder. Click Next to continue.

Destination Folder: ram Files (x86)\Divelbiss Corporation\EZ Ladder Toolkit 1.1.0.0

Space required: 235.8MB
Space available: 742.8GB

6. All the information is gathered. Click **INSTALL** to install the EZ LADDER Toolkit. The EZ LADDER installer will copy all the required files and create a shortcut.


EZ Ladder Toolkit 1.1.0.0 Setup

Choose Start Menu Folder
Choose a Start Menu folder for the EZ Ladder Toolkit 1.1.0.0 shortcuts.

Select the Start Menu folder in which you would like to create the program's shortcuts. You can also enter a name to create a new folder.

Divelbiss Corporation\EZ Ladder Toolkit 1.1.0.0

7-Zip
Accessories
ACT! 6
Administrative Tools
Adobe
Adobe Design Premium CS4
Adobe Design Premium CS5
Adobe LiveCycle ES2
Adobe Master Collection CS6
Alliance
Applications
Ashampoo

7. When installation is complete, click **FINISH**.

Activating the EZ LADDER Toolkit

Until EZ LADDER Toolkit is activated, it will only operated in DEMO mode which does not connecting to actual hardware targets (controllers) or downloading programs.

Now that the EZ LADDER Toolkit is installed, it must be activated to enable all the features. You will need the following to activate your EZ LADDER Toolkit.

1. An internet connection and web browser like Internet Explorer (does not have to be the computer that EZ LADDER is installed on).

2. Your EZ LADDER Toolkit CD Case. You will need your CID Code located on the back of the case.

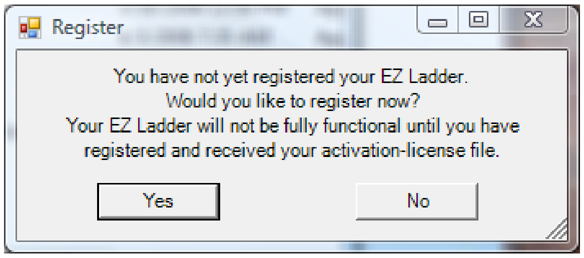
3. EZ LADDER Toolkit installed.

Once activated, EZ LADDER Toolkit is fully functional and will operate with hardware targets. The process of registering and activating is completing the on-line registration form receiving a counter key. This key must be loaded into EZ LADDER Toolkit and when loaded, it will activate your copy of EZ LADDER Toolkit.

If EZ Ladder is not registered, it will prompt you to do so when the application is started.

To activate and register your EZ LADDER Toolkit, follow the installation wizard as follows:

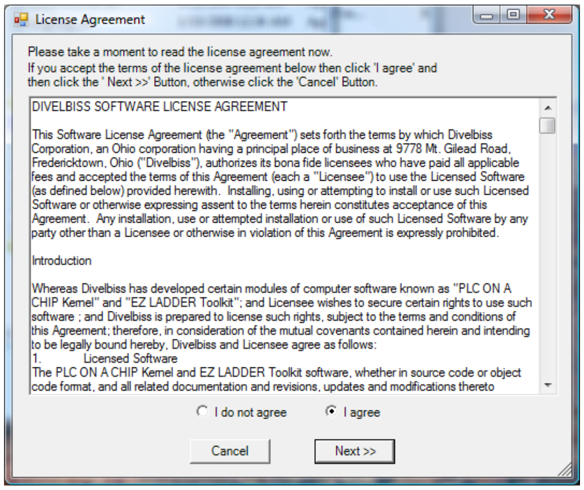
1. When prompted to Activate EZ LADDER, click **YES**.



Register

You have not yet registered your EZ Ladder.
Would you like to register now?
Your EZ Ladder will not be fully functional until you have registered and received your activation-license file.

2. You must read and agree to the license agreement to activate the EZ LADDER Toolkit. Click the **I AGREE** box and click **NEXT**.



License Agreement

Please take a moment to read the license agreement now.
If you accept the terms of the license agreement below then click 'I agree' and then click the ' Next >>' Button, otherwise click the 'Cancel' Button.

DIVELBISS SOFTWARE LICENSE AGREEMENT

This Software License Agreement (the "Agreement") sets forth the terms by which Divelbiss Corporation, an Ohio corporation having a principal place of business at 9778 Mt. Gilead Road, Fredericktown, Ohio ("Divelbiss"), authorizes its bona fide licensees who have paid all applicable fees and accepted the terms of this Agreement (each a "Licensee") to use the Licensed Software (as defined below) provided herewith. Installing, using or attempting to install or use such Licensed Software or otherwise expressing assent to the terms herein constitutes acceptance of this Agreement. Any installation, use or attempted installation or use of such Licensed Software by any party other than a Licensee or otherwise in violation of this Agreement is expressly prohibited.

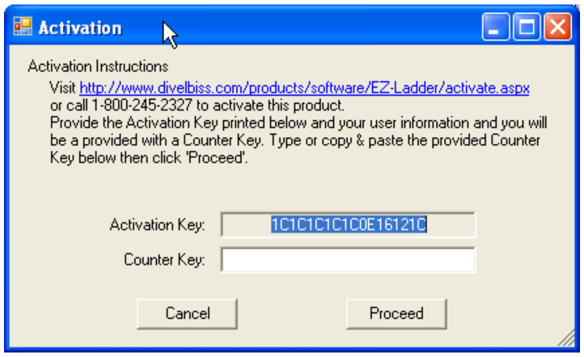
Introduction

Whereas Divelbiss has developed certain modules of computer software known as "PLC ON A CHIP Kernel" and "EZ LADDER Toolkit"; and Licensee wishes to secure certain rights to use such software ; and Divelbiss is prepared to license such rights, subject to the terms and conditions of this Agreement; therefore, in consideration of the mutual covenants contained herein and intending to be legally bound hereby, Divelbiss and Licensee agree as follows:
1. Licensed Software
The PLC ON A CHIP Kernel and EZ LADDER Toolkit software, whether in source code or object code format, and all related documentation and revisions, updates and modifications thereto

I do not agree [✓ I agree]

2. Click the link provided. A web browser window will open to the registration and activation page on Divelbiss.com.

   You will need the Activation key provided by EZ LADDER and your CID Code # located on the back of your EZ LADDER Toolkit CD case.



Activation

Activation Instructions

Visit http://www.divelbiss.com/products/software/EZ-Ladder/activate.aspx
or call 1-800-245-2327 to activate this product.
Provide the Activation Key printed below and your user information and you will be a provided with a Counter Key. Type or copy & paste the provided Counter Key below then click 'Proceed'.

Activation Key: 1C1C1C1C0E16121C

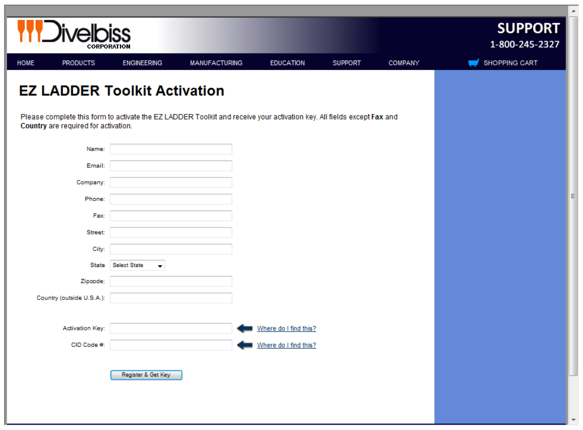
Counter Key:

If you do not have your CID Code #, you must obtain it prior to continuing the activation. Contact Divelbiss Customer Support.

If you close EZ LADDER prior to completing activation, the original Activation Key cannot be used. A new Activation Key must be used to activate the EZ LADDER Toolkit.

3. Click on the link provided to open the browser and go to the Activation Page. Copy / Paste or type your Activation key into the Activation key form box on the web site Activation and Registration page, if not already pre-loaded (Internet Explorer will preload this for you).

4. Complete all other form entries. All information must be completed. The CID Code# is found on the EZ LADDER Toolkit's CD Case (located on back side).



EZ LADDER Toolkit Activation

Please complete this form to activate the EZ LADDER Toolkit and receive your activation key. All fields except **Fax** and **Country** are required for activation.

Name:
Email:
Company:
Phone:
Fax:
Street:
City:
State: Select State
Zipcode:
Country (outside U.S.A.):

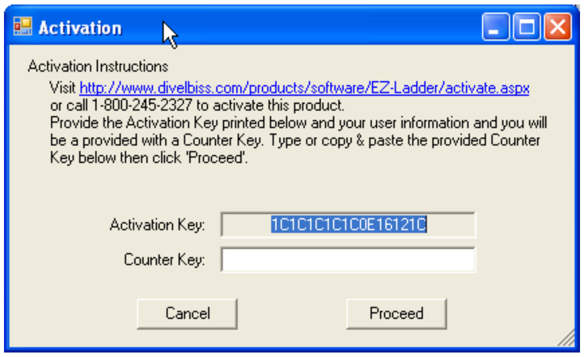
Activation Key: Where do I find this?
CID Code #: Where do I find this?

5. Click the **REGISTER & GET KEY** button. The Activation key and other information will be confirmed and if valid, a *Counter Key*, *Username* and *Password* will be displayed. Save the *Username* and *Password* as they can be used to download updates to EZ LADDER Toolkit.

If the information is not valid, the registration will fail. Activation can fail due to an incorrect Serial Number, incorrect CID Code#, copying the Activation or Counter key incorrectly or if this serial number has been registered more times than allowed per the license agreement (typically 2 times). Check this information. If you are still unable to activate EZ LADDER Toolkit, Contact Divelbiss Customer Support.

6. Copy / Paste or type the *Counter Key* into the Counter Key form box in the EZ LADDER Toolkit Activation Window. Click **PROCEED**.

7. A Dialog box will appear verifying that EZ LADDER has successfully been activated.



Activation

Activation Instructions

Visit http://www.divelbiss.com/products/software/EZ-Ladder/activate.aspx
or call 1-800-245-2327 to activate this product.
Provide the Activation Key printed below and your user information and you will be a provided with a Counter Key. Type or copy & paste the provided Counter Key below then click 'Proceed'.

Activation Key: 1C1C1C1C0E16121C

Counter Key:

Installing Additional Copies of EZ LADDER Toolkit

The standard EZ LADDER Toolkit license agreement allows the EZ LADDER Toolkit to be installed on up to two computers (usually a PC and a laptop). To install on a second computer, install the EZ LADDER Toolkit and Activate it as was done on the original computer.

If you attempt to activate a serial more than two time (unless you have purchased a site license), the activation will fail as the serial number has been activated the maximum number of allowed times.

If you are re-installing due to a hardware failure or moving computers, Contact Divelbiss Customer Support to allow additional activations.

CHAPTER 2

Navigating EZ LADDER Toolkit

This chapter provides detailed information on the basics of navigating and using the EZ LADDER Toolkit's workspace, menus, tool bars and windows.

Chapter Contents

EZ LADDER Toolkit Overview

When the EZ LADDER Toolkit is started, it will open in the ***Edit Mode***. This mode is where ladder diagram projects are created, functions are inserted and variables are placed. When actually downloading ladder diagram projects to targets or monitoring ladder diagram operation on hardware targets, it is referred to as ***Run Mode***. The Run Mode is explained in **Chapter 6 - Downloading and Running Projects**.

Figure 2-1 identifies the components that are part of the Edit Mode.

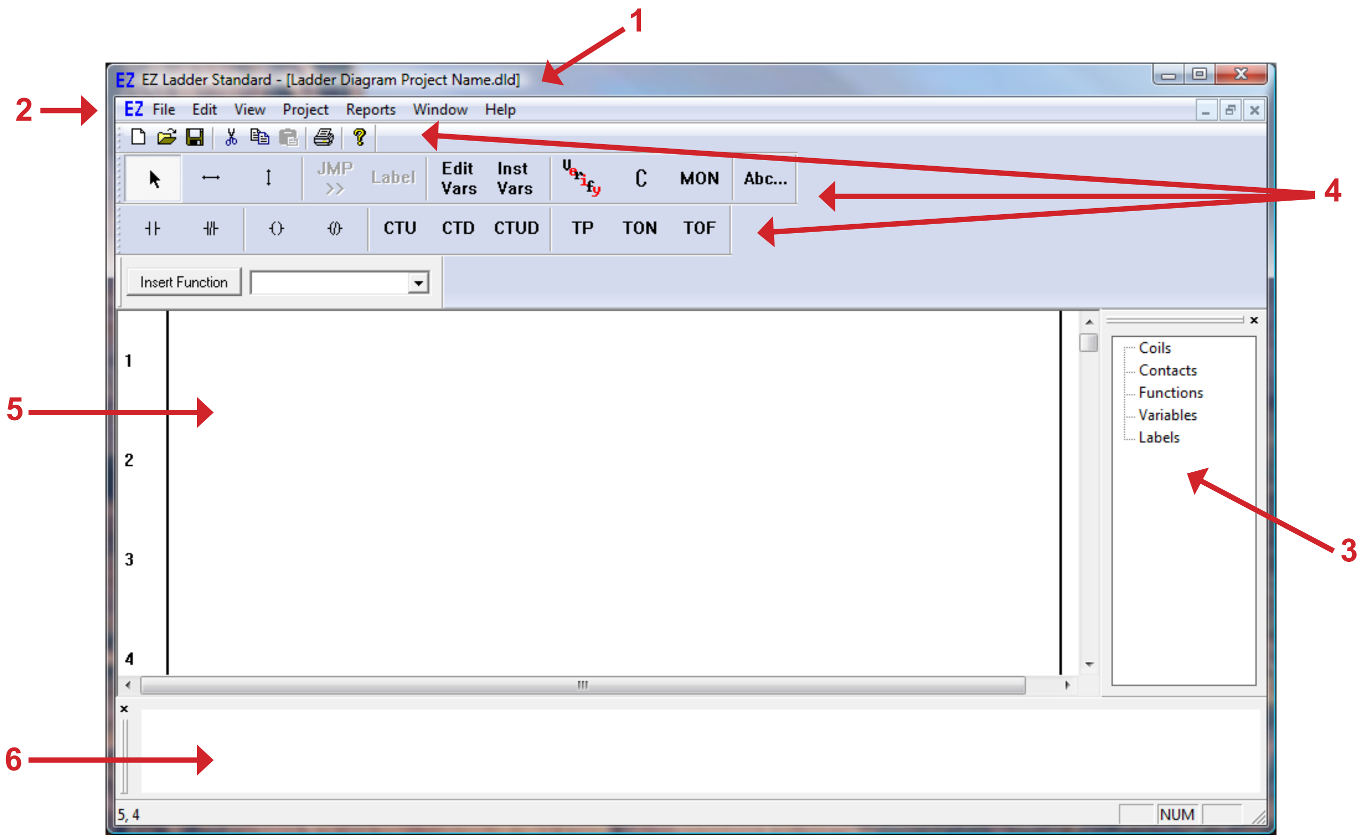


Figure 2-1

1. Project Filename:	The name of the currently viewed project will be displayed in this position.
2. Menus:	Drop-down menus for programming features and options.
3. Cross Reference:	Quick Click Cross References for functions, objects and variables.
4. Tool Bars:	Tool bars for placing functions, objects and drop-down function lists.
5. Ladder Workspace:	Area where the ladder diagram is drawn.
6. Output Window:	This is where status messages are displayed when Verifying or Compiling ladder diagram programs.

EZ LADDER Toolkit Menus

The EZ LADDER Toolkit has many features and options. Basic commands, features and options are used and controlled through drop down menus. Figure 2-2 shows the standard EZ LADDER Toolkit Menu bar. As with any Windows based application, clicking on a menu heading will cause the drop down menu to open.

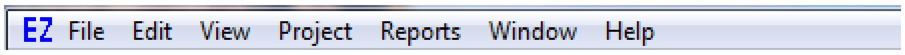


Figure 2-2

The menus found in the EZ LADDER Toolkit are: File, Edit, View, Project, Reports, Window and Help. Some of these menus are specific to EZ LADDER Toolkit features while others are part of the basic Windows structure.

FILE MENU

The FILE Menu includes the standard windows functionality for file control and printing. The FILE Menu items are: New, Open, Close, Save, Save As, Print, Print Preview, Print Setup and Exit. A recently opened file list is also included for quick recall of recently opened ladder diagram projects.

New
The New menu item is used to create a new, blank EZ LADDER Toolkit Ladder Diagram Project.

Open
The Open menu item is select and open a previously saved EZ LADDER Toolkit Ladder Diagram Project.

Close
The Close menu item closes the currently selected EZ LADDER Toolkit Ladder Diagram Project.

Save
The Save menu item is used to save the currently selected EZ LADDER Toolkit Ladder Diagram Project. If the project has not been saved previously, the Save As dialog is displayed.

Save As
The Save As menu item is used to save the currently selected EZ LADDER Toolkit Ladder Diagram Project under a new name.

Print
Opens the Print dialog box for printing the currently selected EZ LADDER Toolkit Ladder Diagram Project with the settings defined in the Print Setup menu.

Print Preview
Opens a window to view the ladder diagram project as it is to be printed.

Print Setup
Opens a window to configure print and printer settings.

Exit
Closes all currently opened ladder diagram projects and closes the EZ LADDER Toolkit application program.

EDIT MENU

The EDIT Menu includes the standard windows functionality for editing and editing preferences. The EDIT Menu items are: Undo, Redo, Cut, Copy, Paste, Select All, Settings.

Undo
The Undo will cause the last action performed to be undone.

Redo
The Redo will cause an action that was undone using the Undo, to be repeated or completed again.

Cut
The Cut menu is disabled in the EZ LADDER Toolkit. To delete an object or multiple objects, select the object(s) using the selector tool and remove by press the **DELETE** key.

Copy
The Copy is disabled in the EZ LADDER Toolkit. To copy an object or multiple objects, select the object(s) using the selector tool, right click the mouse and select **COPY**. This will copy all the selected objects to the Windows clipboard.

Paste
The Paste menu item is disabled in the EZ LADDER Toolkit. To paste an object or multiple objects, position the mouse at the starting point to paste, right click the mouse and select **PASTE**. This will paste the Windows clipboard contents into the ladder diagram project.

When pasting objects and rungs, enough space must be available at the pasting point for the Windows clipboard contents. The paste will not complete unless sufficient space is provided (# of rungs and space on each rung).

Select All
The Select All menu item is disabled in the EZ LADDER Toolkit.

Settings
The Settings menu item opens the LD (ladder diagram) settings window. This window allows general setting to be configured such as displaying grid, fonts, etc. Typically, it is recommended to leave the settings at the factory defaults.

VIEW MENU

The VIEW Menu is used to view currently selected target information and to view or hide tool bars and optional windows.

Target Information

The target information window provides details of the selected hardware target (selected in the Projects Settings menu) including target name, minimum kernel version required for this version of EZ LADDER Toolkit, Supported Objects and Functions, Analog I/O and Digital I/O. The target information may be printed using the provided **PRINT** button.

Basic Components

The Basic Components menu item will cause the basic components tool bar to be visible or hidden. This tool bar includes buttons for the direct contact, inverted contact, direct coil, inverted coil, CTU, CTD, CTUD, TP, TON and TOF functions.

Cross References

The Cross References menu item will cause the Cross Reference Window to be visible or hidden.

Edit Tools

The Edit Tools menu item will cause the edit tools tool bar to be visible or hidden. This tool bar includes buttons for select, horizontal link, vertical link, Edit Vars, Inst Vars, Verify, Compile (C), MON and text boxes (Abc..).

Function List

The Function List menu item will cause the drop down function list to be visible or hidden. This tool bar is used to select and insert functions into the ladder diagram project.

Output

The Output menu item will cause the Output Window to be visible or hidden. This window displays important messages during the Verify and Compile Operations.

During the Compile process, it is important to have this window visible. Information including compile status and errors are displayed here.

Toolbar

The Toolbar menu item will cause the standard windows functions toolbar to be visible or hidden. This tool bar includes, New, Open, Save, Cut, Print and more.

PROJECT MENU

The PROJECT Menu is used to view and configure Project target settings including hardware target selections, and installing and configuring optional target features.

Settings

The Settings menu item opens the Project Settings Dialog. This dialog is used to configure the actual hardware target (controller) and its features. The target is selected from the available list. Depending upon the target selected, additional configuration settings may be required and additional features can be configured from this menu. Refer to **Chapter 4 - Configuring Targets** for detailed information regarding target configurations.

Bootloader

The Bootloader menu item will open the Bootloader dialog window. This window is used to install or update hardware target kernels and to configure some features such as the SD Card, Ethernet and USB.. The Bootloader menu item is only available in the Run Mode.

OptiCAN

The OptiCAN menu item will open the OptiCAN Configuration Tool. This tool is used to configure the OptiCAN network. The OptiCAN menu item is only available in the Run Mode and when OptiCAN is enabled and supported.

REPORTS MENU

The REPORTS Menu is used to generate, view and print reports that may be helpful when developing a ladder diagram project.

Variable Definitions

The Variables Definitions report generates a list of all variables present in the ladder diagram project and their specific information including name, I/O Number, Default Value and their description.

Cross References

The Cross Reference opens the Cross Reference Dialog box. This box is where the criteria for the report is selected. The following are the selectable criteria items: Input, Output, Internal, Function, Unused Variables, Contacts Without Coils, Coils Without Contacts, Drum Sequencer Tables, Retentive Variables and Network Address / Registers. After the required items are selected or deselected, click **OK**. This generates the viewable and printable report.

WINDOW MENU

The WINDOW Menu is the basic Window's menu for viewing and controlling open application windows. This menu is typically found in every Window's based program. Since this functionality is based on Windows, it will not be described in detail.

HELP MENU

The HELP Menu is useful to determine software versions and registration information. Currently, there is no active help built-in to the EZ LADDER Toolkit.

About

Opens the EZ LADDER Toolkit about dialog box. The Toolkit version is displayed at the top of the dialog box. The File Versions tab identifies versions of each of the EZ LADDER Toolkit components. The License Information tab identifies the EZ LADDER Toolkit Serial Number and who it is registered to.

Splash Screen

Opens the EZ LADDER Toolkit splash screen. This screen is normally viewable for a few seconds when EZ LADDER Toolkit is started.

EZ LADDER Toolkit Tool Bars and Tool Bar Buttons

The EZ LADDER Toolkit provides tool bars for many common functions for ease of use and to increase efficiency when programming ladder diagram projects. As discussed earlier, many of these tool bars may be either viewed or hidden. EZ LADDER Toolkit defaults these tool bars as viewable.

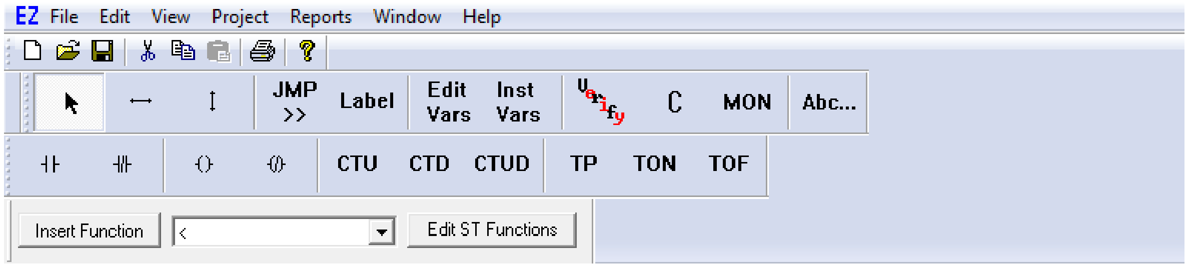


Figure 2-3

Each tool bar contains multiple buttons. The following describes the function of each button.

New Project. Opens a new blank EZ LADDER Toolkit Project Window.

Open Project. Browse and open an existing EZ LADDER Toolkit Project.

Save Project. Saves the currently selected EZ LADDER Toolkit Project.

Cut. Cuts (Deletes) the selected Items.

Copy. Copies the currently selected items to the Window's Clipboard.

Print Project. Opens the Print dialog for printing the EZ LADDER Toolkit Project.

Help. Opens the Help About dialog.

Select Tool. Selects individual or multiple items. Click on item to select or click and drag to select multiple items.

Horizontal Link. Used to draw horizontal links between functions, object and variables.

Vertical Link. Used to draw vertical links between functions, object and variables.

Edit Variables. Opens the Edit Variables Dialog. Variables are created, edited and deleted using this dialog box.

Insert Variables. Clicking in the ladder diagram workspace inserts a variable in that location. The inserted variable is selected from a dialog box that opens.

Verify Program. Verifies the ladder diagram and elements are complete and do not break any rules. This is automatically done when the **COMPILE** button is clicked.

Compile Program. This does an automatic verify and then compiles the ladder diagram project for the specific hardware target (controller).

Monitor Mode. This changes the EZ LADDER workspace from the Edit Mode to the Monitor Mode. The Monitor Mode is where ladder diagram projects are downloaded to and monitored on targets.

Insert Comment. This inserts a comment block into the ladder diagram project.

Direct Contact. This inserts a Direct Contact (Normally Open Contact) into the ladder diagram project workspace wherever you click.

Negated Contact. This inserts a Negated Contact (Normally Closed Contact) into the ladder diagram project workspace wherever you click.

Direct Coil. This inserts a Direct Coil (Normally Open Coil) into the ladder diagram project workspace wherever you click. Can only be placed in last column.

Negated Coil. This inserts a Negated Coil (Normally Closed Coil) into the ladder diagram project workspace wherever you click. Can only be placed in last column.

CTU **Count Up Function**. This inserts a Up Counter Function into the ladder diagram project workspace wherever you click.

CTD **Count Down Function**. This inserts a Down Counter Function into the ladder diagram project workspace wherever you click.

CTUD **Count Up and Down Function**. This inserts an Up and Down Counter Function into the ladder diagram project workspace wherever you click.

TP **Pulse Timer Function**. This inserts an Pulse Timer Function into the ladder diagram project workspace wherever you click.

TON **On Timer Function**. This inserts an ON Timer Function into the ladder diagram project workspace wherever you click.

TOF **Off Timer Function**. This inserts an OFF Timer Function into the ladder diagram project workspace wherever you click.

Insert Function < This is used to insert any function (specifically those functions that do not have a quick used tool bar button. Select the function from the drop down menu and click the Insert Function button. This will place the function into the ladder diagram project workspace wherever you click.

Edit ST Functions **Edit ST Functions**. Opens the EZ LADDER Toolkits Structured Text Function Editor. This window is used for configuring structured text items. For more information on structured text, See **Chapter 26 - Structured Text**.

Ladder Diagram Workspace

The ladder diagram workspace is the area of the screen where objects and links are placed to create the ladder diagram program. Most objects can be placed at any location in the workspace provided there is actual space available. The DIRECT coil, Negated coil, LATCH coil and UNLATCH coil are the only objects that must be placed in a particular location. They must be located in the last column (next to the right power rail). Any attempt to place one of them in another location will cause an error dialog box to be displayed.

A ladder diagram is created using *rungs*. A rung is a horizontal line of logic. EZ LADDER Toolkit allows the maximum number of rungs to be configured when the target is selected in the **Project Settings** dialog. Figure 2-4 shows the ladder diagram workspace and rungs of horizontal logic.

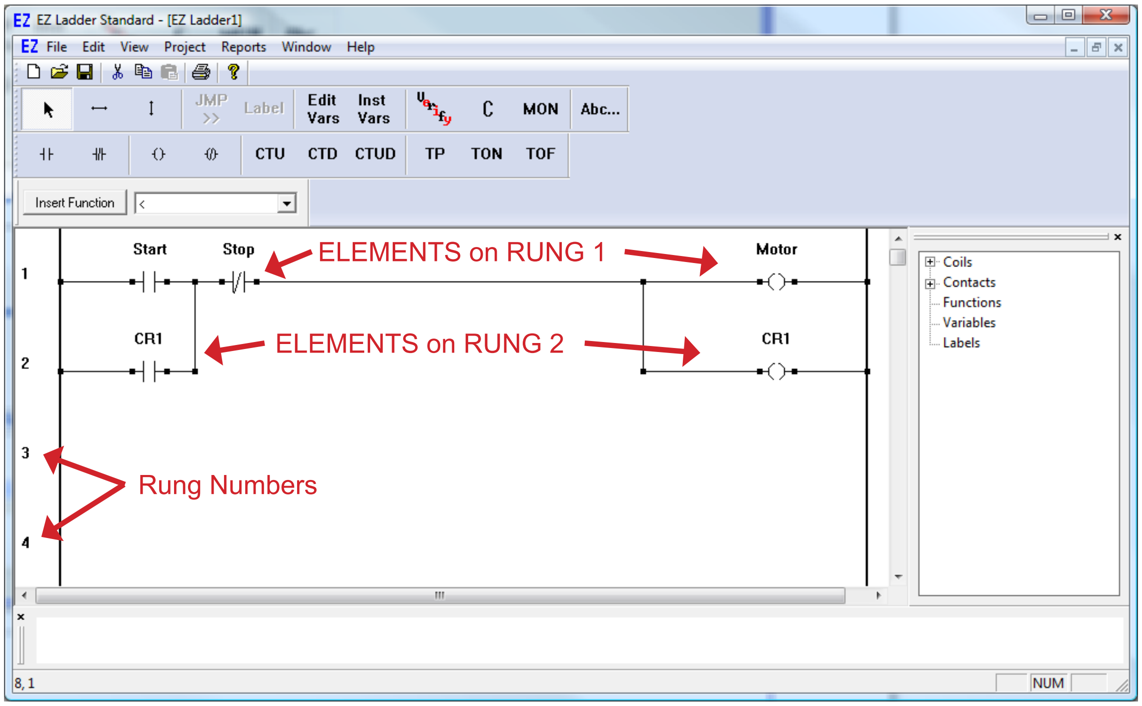


Figure 2-4

Cross Reference Window Pane

EZ LADDER Toolkit provides a real-edit-time Cross Reference Window. This window provides lists of contacts, coils, variables, and functions as well as their location by rung. This quick reference provides an easy method to locate where a contact or other function is located in the ladder diagram program. Figure 2-5 shows the Cross Reference Window. Cross references are updated automatically when objects change.

This window may be used to find objects quickly. Double-click on any of the object rung numbers listed for an object or function and EZ LADDER Toolkit will locate and display that section of the ladder diagram.

The Cross Reference Window may be viewed or hidden by using the **View Cross References** Menu.

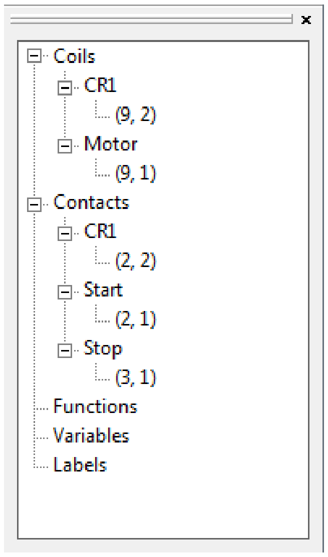
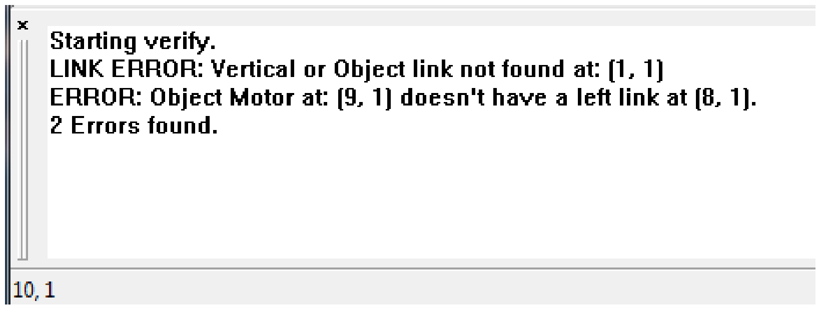


Figure 2-5

Output Window Pane

EZ LADDER Toolkit provides an Output Window pane where error messages are displayed. Typically, error messages are only updated and displayed during a **Verify** operation or **Compile** operation. Figure 2-6 displays an example error identified during a compile process.

When an error message identifies a location, (i.e.: "ERROR: Object Motor at: (9,1) doesn't have a left link at (8,1)), the first number in the location refers to the column in the workspace while the second number refers to the actual rung number where the error occurs (Column, Rung).



```
Starting verify.
LINK ERROR: Vertical or Object link not found at: (1, 1)
ERROR: Object Motor at: (9, 1) doesn't have a left link at (8, 1).
2 Errors found.
```

10, 1

Figure 2-6

If the Output Window is not visible and an error is detected during a compilation, the Output Window will be reset to a visible state to announce the error.

Opening Existing Ladder Diagram Project Files

Existing ladder diagram project files may be opened and manipulated by editing, downloading and saving. To open an existing ladder diagram project (.dld) file, use the File...Open menu.

Password protection is enforced if enabled in the project settings. When enabled, to open the ladder diagram file, you will be required to enter a password that will be compared against the ladder diagram file's credentials list. Only allowed permissions for the password entered will be allowed. If the password entered is not in the list, then the ladder diagram file cannot be opened or viewed. Refer to **Chapter 25 - Password Protection** for password details.

CHAPTER 3

Ladder Diagram Basics

This chapter provides detailed information on understanding the origin of ladder diagrams as they relate to original relay logic, basic ladder diagram symbols, power rails, links, types of circuit connections and ladder diagram functionality.

Chapter Contents

Relay Logic vs Ladder Diagram

Prior to the invention of the Programmable Logic Controller (PLC), control panels consisted of large numbers of relays, motor starters and other devices, wired to create the required functionality. Today, with the use of PLCs, the same functionality is achieved by drawing the circuit functionality in software; similar to the original relay logic panel wiring diagrams were drawn.

Ladder Diagram is a graphical representation of boolean equations, using contacts (inputs) and coils (outputs). The ladder diagram language allows these features to be viewed in a graphical form by placing graphic symbols into the program workspace similar to a Relay Logic electrical diagram. Both ladder diagram and relay logic diagrams are connected on the left and right sides to power rails.

A comparison of a *hard-wired* relay logic system and a *programmable* system using EZ LADDER Toolkit as the programming platform will show the similarities which make the programming using EZ LADDER Toolkit quick and easy to apply to any application.

Figure 3-1 shows a block diagram on the left and the *hard-wired* relay logic control system on the right. For easy comparison, it is divided into three sections.

Input Devices: Includes devices operated manually (i.e.: push buttons) and devices operated automatically (i.e.: limit switches) by the process or machine being controlled.

Relay Control Logic: Consists of relays interconnected to energize or de-energize output devices in response to status of input devices, and in accordance with the logic designed into the control circuit.

Output Devices: Consists of motor starters, solenoids, etc. which would control the machine or process.

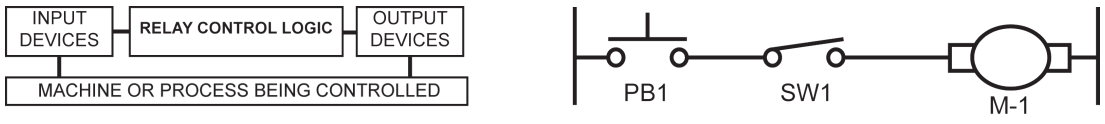


Figure 3-1

In place of *hard-wired* relay logic circuitry, EZ LADDER Toolkit applications are programmed using *relay-type symbology*. This symbology brings ease and familiarity to the programming while adding flexibility. Figure 3-2 is the same circuit as shown in Figure 3-1 as it is programmed using the EZ LADDER Toolkit's *relay-type symbology*.

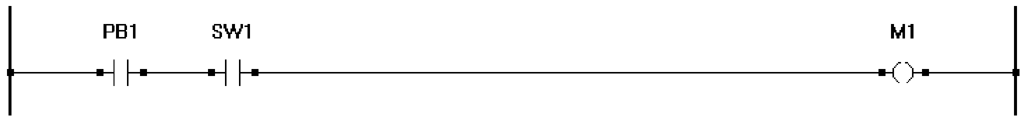


Figure 3-2

Basic Ladder Diagram Symbols

In ladder diagram, all devices are represented by symbols (objects and function blocks). **Chapter 24 - Function Reference** provides detailed descriptions for all EZ LADDER Toolkit objects and function blocks. This section will give a basic information regarding the most commonly used objects.

Contacts

Contacts represent two types of devices. The first is real world digital input (devices) such as limit switches, push-button switches, and proximity sensors. The second is that contacts may represent ***internal relays***; also named ***control relays*** (CRs). When acting as a real world input, the ladder diagram object will represent the current state of the real world input it is assigned. When used as an internal control relay, the contact will represent the current state of the control relay's *coil*.

Contacts are represented in the EZ LADDER Toolkit by two different objects: Direct Coil and Negated Contact.

Contacts are always shown in their at-rest or un-powered state.

Direct Contact ┤├

Also known as a normally open contact, the direct contact may represent real world inputs or internal relay contacts. As a real world input, when the input is energized (TRUE), it will be represented by a TRUE condition in the ladder diagram; causing power to flow through it to any following objects and function blocks. As a real world input, when the input is de-energized (FALSE), it will be represented by a FALSE condition in the ladder diagram; not allowing power to flow through it to any following objects and function blocks. When used as an internal relay, the state of the contact (TRUE or FALSE) depends upon its internal coil state.

Negated Contact ┤/├

Also known as a normally closed contact, the negated contact may represent real world inputs or internal relay contacts. As a real world input, when the input is energized (TRUE), it will be represented by a FALSE condition in the ladder diagram; not allowing power to flow through it to any following objects and function blocks. As a real world input, when the input is de-energized (FALSE), it will be represented by a TRUE condition in the ladder diagram; causing power to flow through it to any following objects and function blocks. When used as an internal relay, the state of the contact (TRUE or FALSE) depends upon its internal coil state and is always opposite of the Direct Contact.

Coils

Coils represent two types of devices. The first is real world digital output (devices) such as solenoids, valves and motors. The second is that coils may represent ***internal relays***; also named ***control relays*** (CRs). When acting as a real world output, the ladder diagram object will control the current state of the real world output it is assigned. When used as an internal control relay, the coil will control the current state of the control relay's *coil*.

Direct Coil -( )-

Also known as a normally open coil, the direct coil may represent real world outputs or internal relay coils. As a real world output, when the coil is energized (TRUE), it will be cause the real world output to be TRUE (energized). As a real world output, when the coil is de-energized (FALSE), it will cause the real world output to be FALSE (de-energized). When used as an internal relay, it controls it's contact(s) state.

Negated Coil -(/)-

Also known as a normally closed coil, the negated coil may represent real world outputs or internal relay coils. As a real world output, when the coil is energized (TRUE), it will cause the real world output to be FALSE (de-energized). As a real world output, when the coil is de-energized (FALSE), it will be cause the real world output to be TRUE (energized). When used as an internal relay, it controls it's contact(s) state and is always opposite of the Direct Coil.

Power Rails and Links

Power Rails

As previously discussed, an EZ LADDER Toolkit ladder diagram contains objects (contacts, coils and function blocks). For the ladder diagram to operate correctly, each rung must be complete on each side by connecting it to the **left power rail** and the **right power rail**. This is required because all objects in a rung must have a power source (the left power rail) to provide power to the objects and a common return (right power rail) to complete the circuit.

Power rails run the entire length of an EZ LADDER Toolkit project. Figure 3-3 shows a typical ladder diagram rung and identifies the power rails. Please note, the rung is connected to both the right and left power rails.

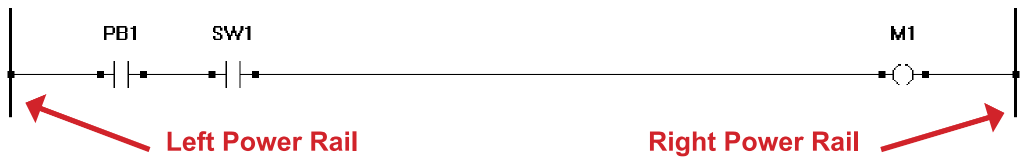


Figure 3-3

Links

As discussed previously, a rung must be complete and connected to both power rails for proper operation. Links (Horizontal and Vertical) are used to connect objects and function blocks to other objects and function blocks as well as to power rails. Horizontal Links connect devices horizontally or on the same rung. Vertical Links connect devices on different rungs. Consider each link like an electrical wire that is needed to connect devices in a circuit. Figure 3-4 identifies the types of links.

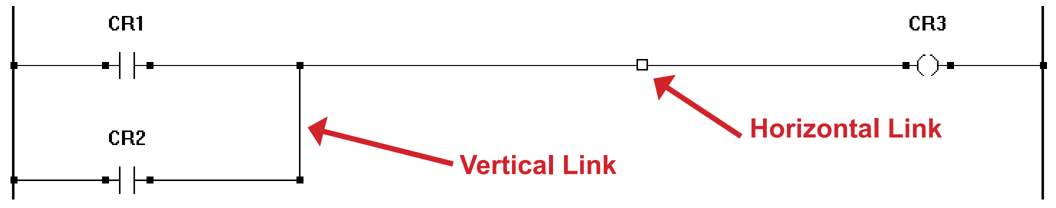


Figure 3-4

Connection Types

As seen in previous sections, the use of power rails, horizontal and vertical links creates a wide variety of ways to draw ladder diagram circuits. Below are some typical connection types. They are created by using horizontal and vertical links.

Simple Series Connection

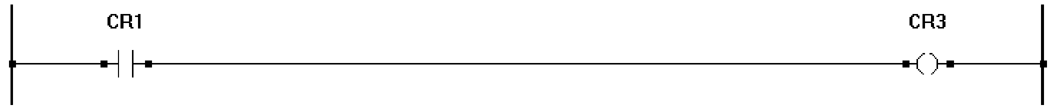


Figure 3-5

Multiple Device Series Connection

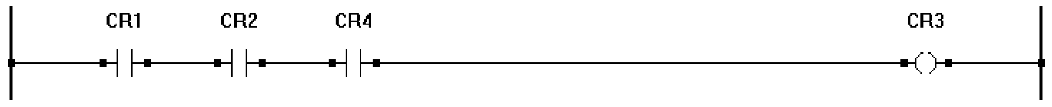


Figure 3-6

Parallel Connection

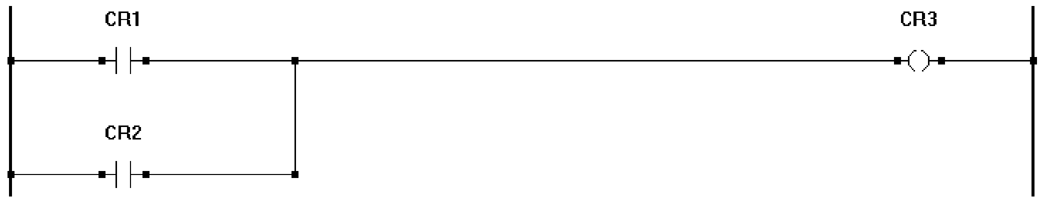


Figure 3-7

Complex Series / Parallel Connection

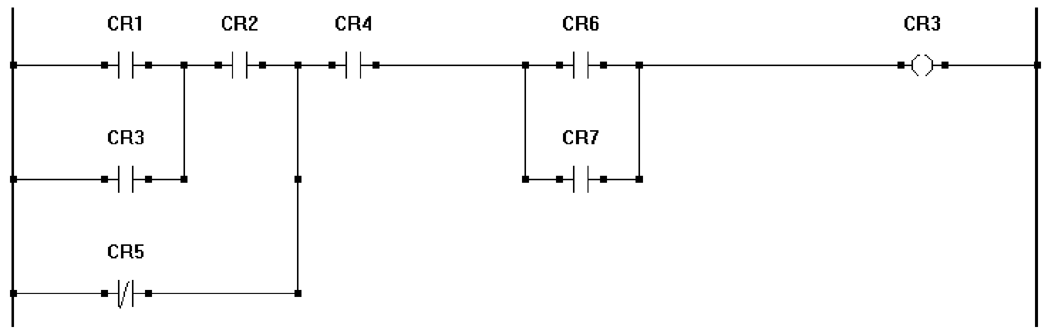


Figure 3-8

Understanding Ladder Diagram Functionality

When a ladder diagram is installed on a PLC or other controller, it will *scan* the program from top to bottom and left to right. A *scan* is similar to reading a page. A page is read from top to bottom reading each line left to right. One complete reading of the program is considered a ***scan***. The larger the ***scan time*** (one complete read cycle), the less often any real world I/O devices are monitored and controlled. ***Scan time*** is an important consideration in the design of a ladder diagram. This scan time may be viewed in the Monitor Mode when running a ladder diagram with a hardware target.

Figure 3-9 diagrams the functionality and order which a ladder diagram functions.

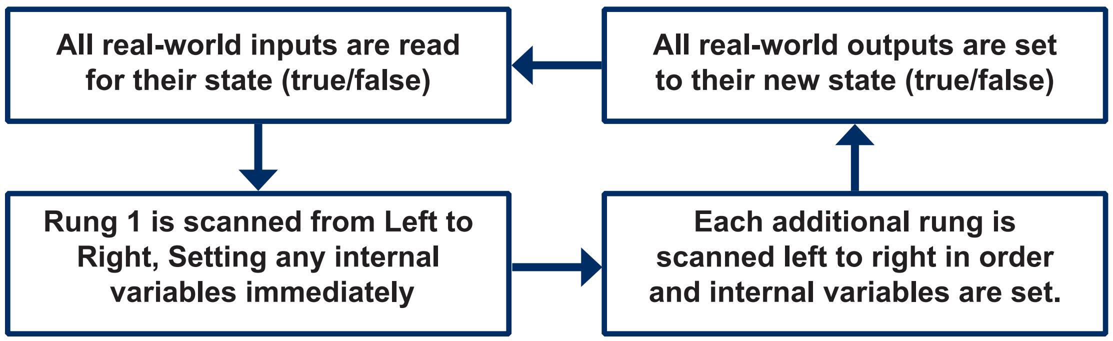

All real-world inputs are read for their state (true/false)
All real-world outputs are set to their new state (true/false)
Rung 1 is scanned from Left to Right, Setting any internal variables immediately
Each additional rung is scanned left to right in order and internal variables are set.

Figure 3-8

CHAPTER 4

Configuring Targets

This chapter provides basic information and steps required to identify, select and configure hardware targets (actual hardware controllers or PLCs) in the EZ LADDER Toolkit.

Chapter Contents

Understanding Targets

A *Target* is the term used in the EZ LADDER Toolkit to describe the actual electronic hardware controller or Programmable Logic Controller (PLC) to which the ladder diagram is specifically written to operate on. Generally, most ladder diagrams can be utilized on different hardware targets with only minor changes to the ladder diagram program itself.

Each hardware target is unique in that each usually have differing number of inputs, outputs, analog I/O and other features. Due to the differences, in each EZ LADDER Toolkit ladder diagram project, the actual target must be identified (selected) and it's optional features (if any) installed and configured properly. Refer to **Chapter 23 - Hardware Targets** for specific target details for each supported target.

It is important to understand that using PLC targets such as, Harsh Environment Controllers, etc typically have some features that require additional configuration after the actual hardware target is selected; while targets such as the PLC on a Chip require you to install and configure each and every I/O point, device and feature you intend to use.

Failure to correctly select, install or configure a feature in the Project Settings may result in the target not operating as anticipated or features and functions not showing available for the target.

For a target to be able to use the compiled ladder diagram program created using the EZ LADDER Toolkit, it must also have its **kernel** installed. The kernel is the hardware target's basic operating system or bios. The kernel is required before any compiled programs can be installed. The kernels for targets are automatically installed on your computer when the EZ LADDER Toolkit is installed. They are typically found in C:\Program Files\Divelbiss\EZ Ladder\Kernel\.

Hardware targets ship from the factory **without a kernel** installed. The kernel must installed prior to downloading the first ladder diagram program. The target is shipped without a kernel to provide greater flexibility in version control.

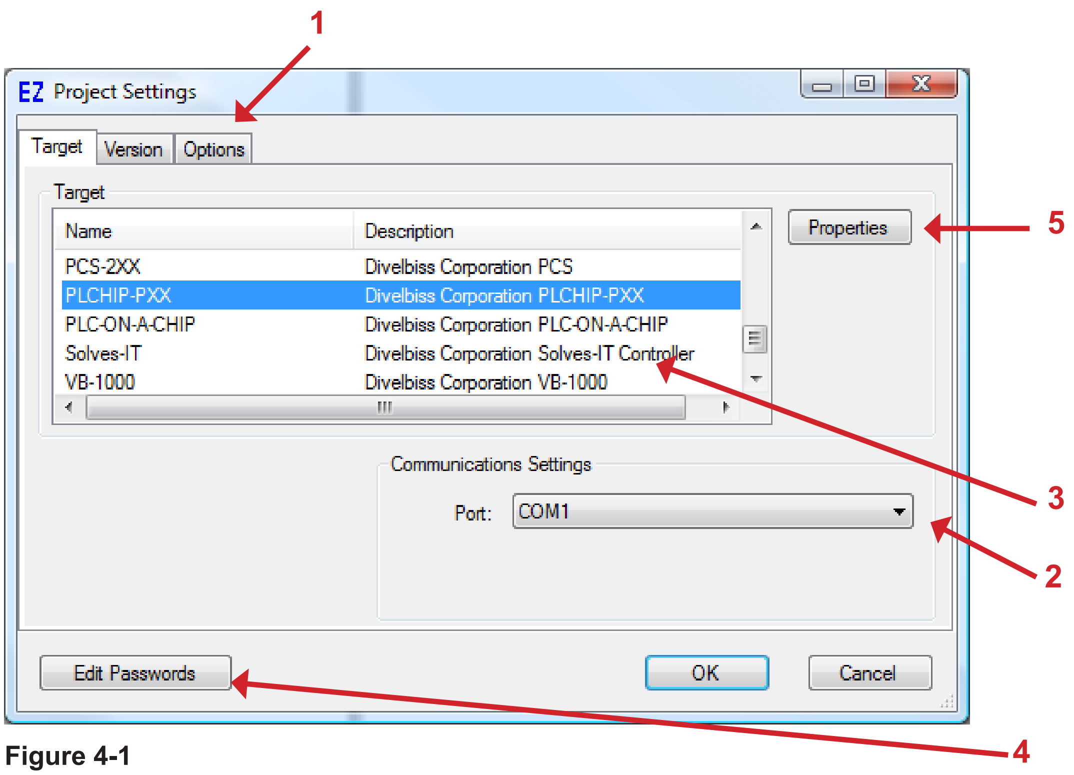
The Project Settings Window

To create a ladder diagram project in EZ LADDER Toolkit, you must first select the hardware target. If you attempt to place any ladder diagram objects in the workspace prior to selecting a target, the Project Settings Window will open requiring you to select the target automatically. EZ LADDER Toolkit uses the target selection to filter and display only ladder diagram objects and functions supported by the selected target.

Only the actual hardware target that will be used should be selected. Selecting a different target will allow the use of objects and function blocks that may not be supported by the actual hardware target as well as not allow use of objects and function blocks that are supported.

To select the target, either try to place a ladder diagram object in the workspace or use the **Project Menu** and click **Settings.** The Project Settings Window / Dialog box will open. Figure 4-1 is an example of the Project Settings Window and identifies the main components of it.

While all targets are displayed in the Project Settings (M-Series or P-Series), the focus will be on the P-Series products and target configurations.



Target

Name	Description
PCS-2XX	Divelbiss Corporation PCS
PLCHIP-PXX	Divelbiss Corporation PLCHIP-PXX
PLC-ON-A-CHIP	Divelbiss Corporation PLC-ON-A-CHIP
Solves-IT	Divelbiss Corporation Solves-IT Controller
VB-1000	Divelbiss Corporation VB-1000

Communications Settings

Port: COM1

Figure 4-1

Target Tab Settings

1. **Project Setting Tabs**: Select the appropriate tab to configure target settings. Figure 4-1 represents the ***TARGET*** tab, Figure 4-2 represents the ***VERSION*** tab, and Figure 4-3 represents the ***OPTIONS*** tab. Clicking on a tab selects the tab for viewing.

2. **Serial Settings**: Select the serial port on the computer that will be used to communicate to the target. These settings are used to connect, download and monitor ladder diagram programs running in EZ LADDER's program run and monitor mode. The baud rate for all hardware targets is automatically set in EZ LADDER and cannot be changed.

3. **Target List**: This is a list of all targets supported by your version of EZ LADDER Toolkit. Click on the target name to select.

   When selecting some targets, an additional dialog may open depending on the hardware target selected.

4. **Edit Passwords**: This button opens Password Setup Dialog box. This box is used to configure a Master Password for the project and additional user / passwords and permissions for others to view, edit, etc.

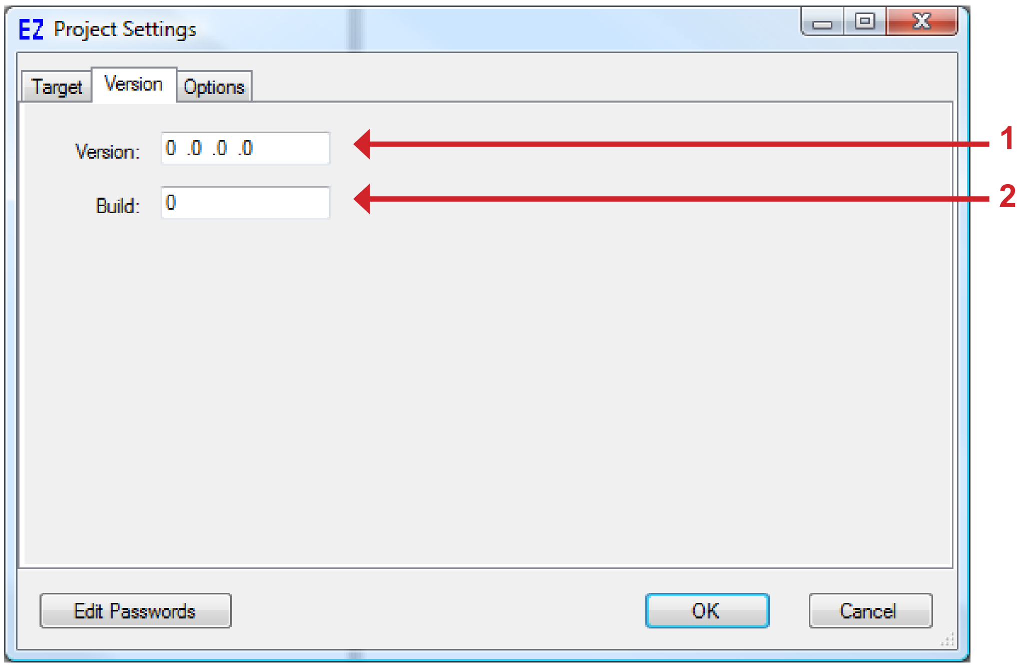
5. **Properties**: When a target has been selected, the **PROPERTIES** button may appear (target specific). If this button appears, clicking the **PROPERTIES** will allow additional configurations for the selected target. Properties may include: Model Number and installing / removing additional target supported features (Modbus, OptiCAN, Ethernet, etc).

Version Tab Settings

The Version Tab will display the current build and version of the ladder diagram that is currently active in the EZ LADDER Toolkit. The build and version information is useful when determining if a program version is current. Figure 4-2 shows the Version settings tab of the Project Setting Window. Version setting may be changed in this window, if required.

1. **Version Number**: A version number for the ladder diagram may be entered here. This number will not change automatically. It must be manually adjusted for each revision or release of the ladder diagram project.

2. **Build Number**: The current build number is displayed here. Each time the ladder diagram project is *Compiled*, the build number automatically increments. This number may be over-written in this window if needed.



Version: 0 .0 .0 .0

Build: 0

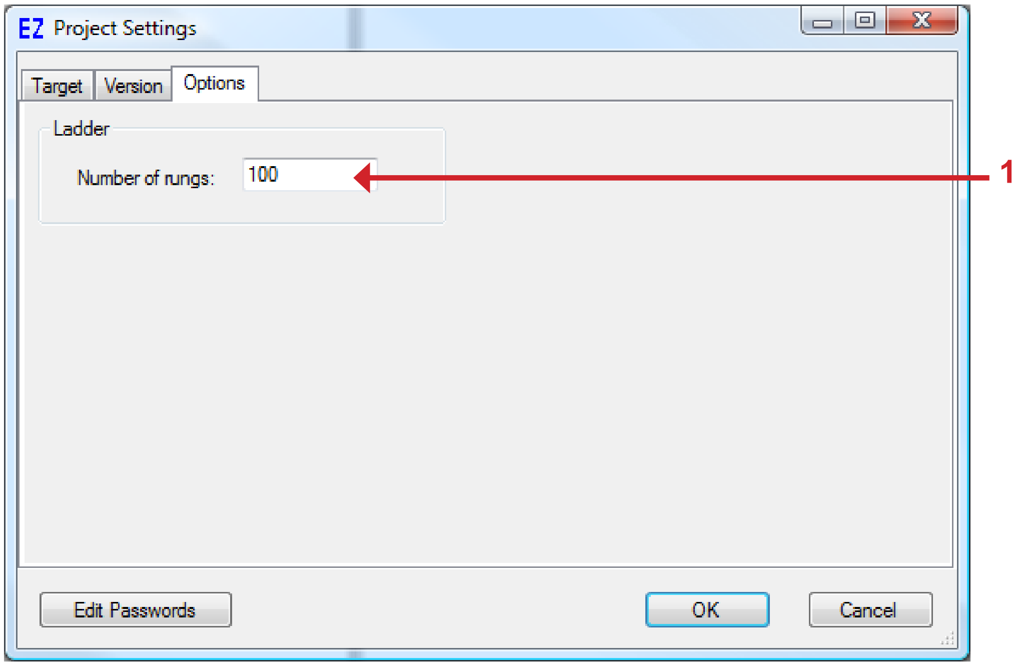
Figure 4-2

Options Tab Settings

The Options Tab will display the currently selected options and preferences. Some of these options are target specific while others are standard. Figure 4-3 shows the Options settings dialog box.

1. Number of Rungs: This is where the maximum number of rungs in the ladder diagram is specified. The default number is 100 rungs.

Inserting or Deleting rungs in an EZ LADDER Toolkit ladder diagram project will change this number accordingly. This number should be considered a starting number of rungs. If the number of rungs is not sufficient for the program size, return to this dialog and adjust the number of rungs. The number of rungs may be adjusted at any time.



Number of rungs: 100

Figure 4-3

Selecting the Hardware Target

As discussed in a previous section, using the dialogs, select the target from the list. If required, select the actual model number, configure any features that you wish to use and click OK. **Chapter 23 - Hardware Targets** includes additional information for each supported hardware target.

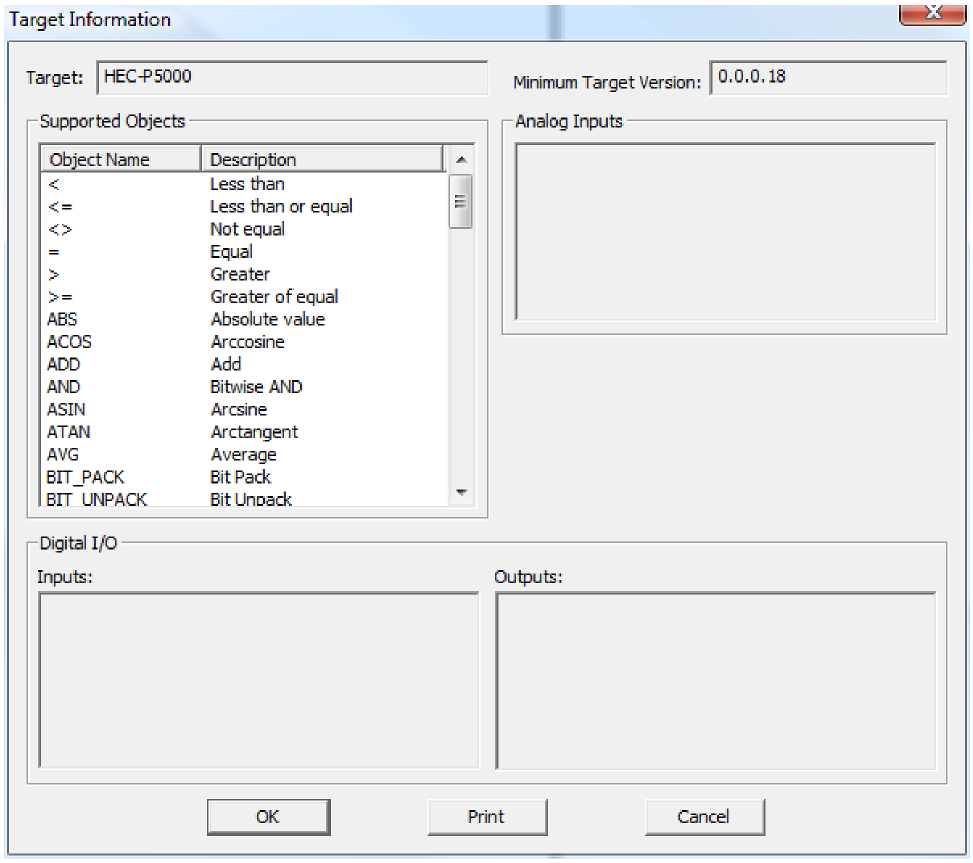
To save the target selection, you must save the ladder diagram project using the **Save** or **Save As** menu items. Hardware Target Selections are for the currently open and active EZ LADDER Toolkit ladder diagram project only. For each new project, you must repeat the hardware target selection and configuration process.

Viewing Target Information

EZ LADDER Toolkit provides includes a built-in quick reference tool to identify what I/O, Analog and functions are supported by a target. The first step is selecting a hardware target as previously shown. To view the target supported features, from the **View** menu, click **Target Information**. The Target Information window will open as shown in Figure 4-4.

This window identifies: the Target Name, Minimum Target Kernel Version that is needed for this version of EZ LADDER Toolkit, Supported Objects and Function Blocks, Analog Inputs, Digital Inputs and Digital Outputs.

The Target Information is printable using the **PRINT** button.



Target: HEC-P5000

Minimum Target Version: 0.0.0.18

Object Name	Description
<	Less than
<=	Less than or equal
<>	Not equal
=	Equal
>	Greater
>=	Greater of equal
ABS	Absolute value
ACOS	Arccosine
ADD	Add
AND	Bitwise AND
ASIN	Arcsine
ATAN	Arctangent
AVG	Average
BIT_PACK	Bit Pack
BIT_UNPACK	Bit Unpack

Figure 4-4

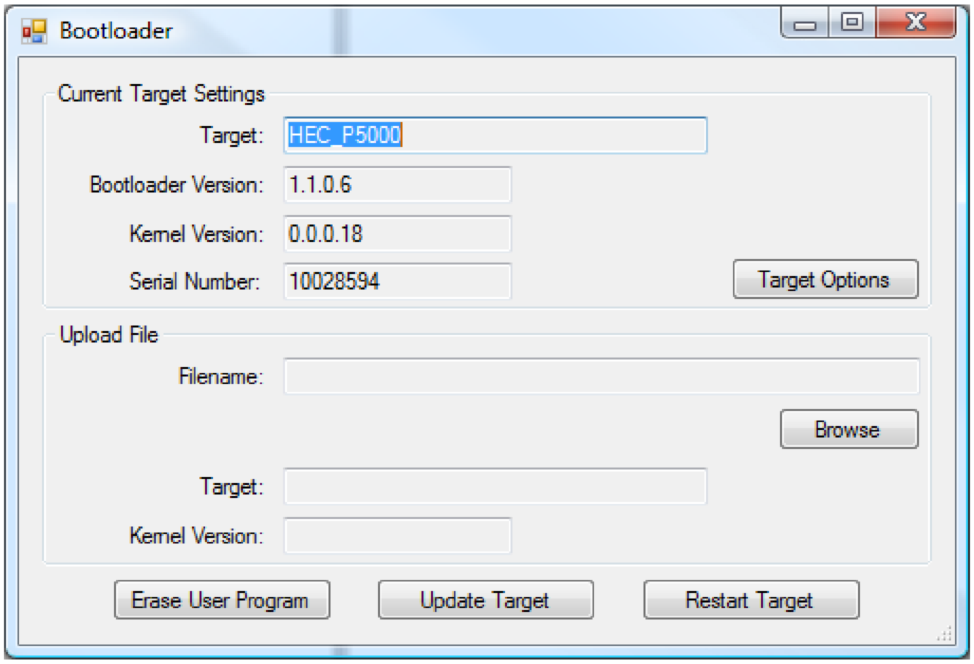
Updating / Installing Target Kernels

As new targets, functions and features are added to the EZ LADDER Toolkit and new versions of EZ LADDER Toolkit are developed and released, to take advantage of newer features, it will be necessary to update the actual target's kernel with newer version.

These same steps may be taken to install a kernel in a target that is new as all new targets from the factory do not have kernels installed.

EZ LADDER Toolkit provides an easy way to update the kernel on the hardware target.

1. Obtain the new kernel for the target (provided by Divelbiss via CD, e-mail or download).
2. Start EZ LADDER Toolkit and open any project that uses the target or create a new project with the actual hardware target selected. This project must have at least one rung of ladder. Compile the program if not already compiled.
3. Verify the Serial Port Settings and connect the target to the computer.
4. Enter the Monitor Mode.
5. From the **Project** menu, select **Bootloader**.
6. EZ LADDER will connect to the target and the Bootloader dialog will open showing the current version of the target's kernel (if any). It will also display the target's bootloader version. See Figure 4-5.


Bootloader

Current Target Settings

Target: HEC_P5000

Bootloader Version: 1.1.0.6

Kernel Version: 0.0.0.18

Serial Number: 10028594

Upload File

Filename:

Target:

Kernel Version:

Figure 4-5

6. Click the **ERASE USER PROGRAM** button to erase the ladder diagram project on the target (if any).

   It is highly recommended that the user program be erased before updgrading a kernel.

7. Click **BROWSE** and select the kernel file for the hardware target. The dialog will update showing the selected kernel file version in the Upload File section of the Bootloader dialog box.

8. To update or install the new kernel, click **UPDATE TARGET**. A status box will appear indicating the status of the kernel installation. During this, the new kernel is being installed. This may take several minutes.

   When updating or installing a kernel, DO NOT REMOVE the CABLE or the POWER. If interrupted during this process, the target will be corrupted and return to a bootloader mode. You must repeat all the above steps again.

   Only the correct target's kernel may be installed into a target. The target is checked against the kernel automatically and will display an error if the wrong kernel is selected and an update is attempted. If a wrong kernel is somehow loaded, contact Divelbiss Technical Support for help regarding removing incorrect kernels.

Recovering Communications

EZ LADDER Toolkit provides additional target utilities that may be used correct actual target problems and restore communication from EZ LADDER to the target. Although rare, occasionally, targets get corrupted and communications cannot be established using normal methods. This can be caused by not erasing a ladder diagram prior to upgrading kernels, wrong kernels installed and interruptions during kernel installations.

The bootloader is installed at the factory and can not be updated outside the factory environment.

When Unable to Connect to the Target

The following steps may be taken if you can verify the connection problems is with the actual hardware target unit specifically (another unit connects with the same setup and program).

1. Start EZ LADDER Toolkit and open any project that uses the target or create a new project with the actual hardware target selected. This project must have at least one rung of ladder. Compile the program.

3. Verify the Serial Port Settings and connect the target to the computer.

4. Enter the Monitor Mode.

5. Press the **F11** key on your computer's keyboard. The dialog box in Figure 4-6 will open.

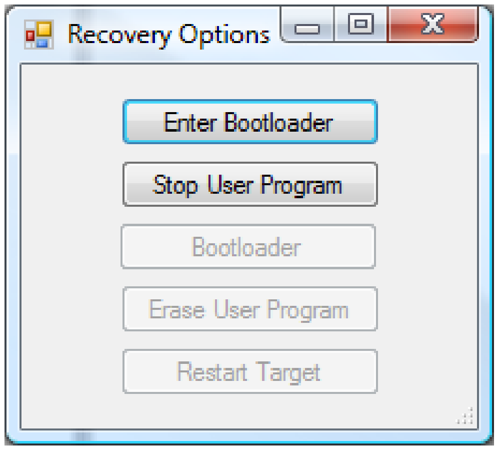


Figure 4-6

6. Disconnect power from the hardware target.

7. Click the **ENTER BOOTLOADER** button in the dialog box. A timing dialog box will appear. This is amount of time that is remaining to re-apply power to the hardware target.

8. Apply power to the hardware target. If the time has elapsed, repeat steps 6-8 again. The hardware target will now allow bootloader operations (other buttons are now active).

9. Choose the correct option to try and resolve your target issue.

Bootloader:	Bootloader will open the bootloader dialog box for updating kernels.
Erase LD Program:	Erases the ladder diagram project from the hardware target's memory. In the event the program is hanging and preventing a normal connection, this will erase the program to allow a normal connect.
Restart Target:	Causes the hardware target to reboot. This is required when all other bootloader actions have been completed. Without the restart, the kernel will still not connect normally.

Using the Restart Target is the same as resetting the power to the hardware target. Both will cause the target to restart and operate normally.

If the incorrect kernel has been installed or there is a corrupt kernel installed, from this screen, press the F11 key. A dialog will appear asking if you are sure you want to erase the kernel. To erase the kernel and reset the target to a blank target, click the **YES**. If you don't wish to erase the kernel, click **NO**. This is how the kernel may be erased.

When a Kernel or User Program is erased, there is no recovery. Erasing a Kernel / User Program should only be done after verification that these items are available to install / re-install.

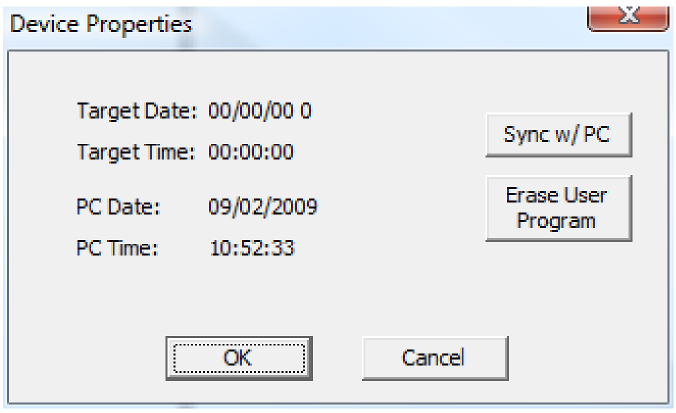
Target Utilities

When communications is present between EZ LADDER and the hardware target, there are additional options / utilities available when connected to the target.

When Able to Connect to the Target

If you can connect normally to the target, there are only a few additional utilities available in the EZ LADDER Toolkit.

1. If the target is connected to normally, press the **F11** key on your computer's keyboard. The Device Properties dialog box will appear as in Figure 4-7.


Device Properties

Target Date: 00/00/00 0
Target Time: 00:00:00
PC Date: 09/02/2009
PC Time: 10:52:33

Figure 4-7

If the actual hardware target does not support a Real Time Clock, then an error dialog box may appear if you were successfully, connected to the hardware target prior to press the **F11** button. Click **OK** to continue.

From this dialog, you can compare the actual computer time and date to the current time and date set on the hardware target. If you wish to synchronize the time (set the hardware target to the computer time), click the **SYNC W/ PC** button. The times should now be synchronized.

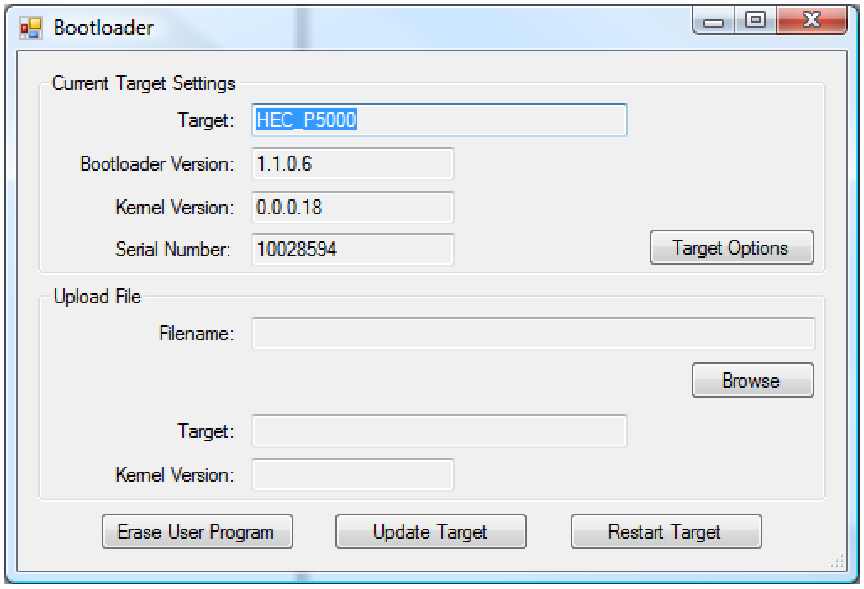
The ladder diagram project can be erased from this dialog by pressing the **ERASE USER PROGRAM** button.

Use caution when deleting the ladder diagram project from the target. There is no Undo. To reload the hardware target, the original ladder diagram project must be opened, compiled and reloaded to the target.

Bootloader Target Options & Configurations

When communications is present between EZ LADDER and the hardware target, there are additional options available in the Bootloader dialog based on the actual target connected. These options are target dependent and the dialogs associated are used to configure the options.

In the Bootloader dialog, click the TARGET OPTIONS button. See Figure 4-8. The Target Options dialog box will open.



Bootloader

Current Target Settings

Target: HEC_P5000

Bootloader Version: 1.1.0.6

Kernel Version: 0.0.0.18

Serial Number: 10028594

Figure 4-8

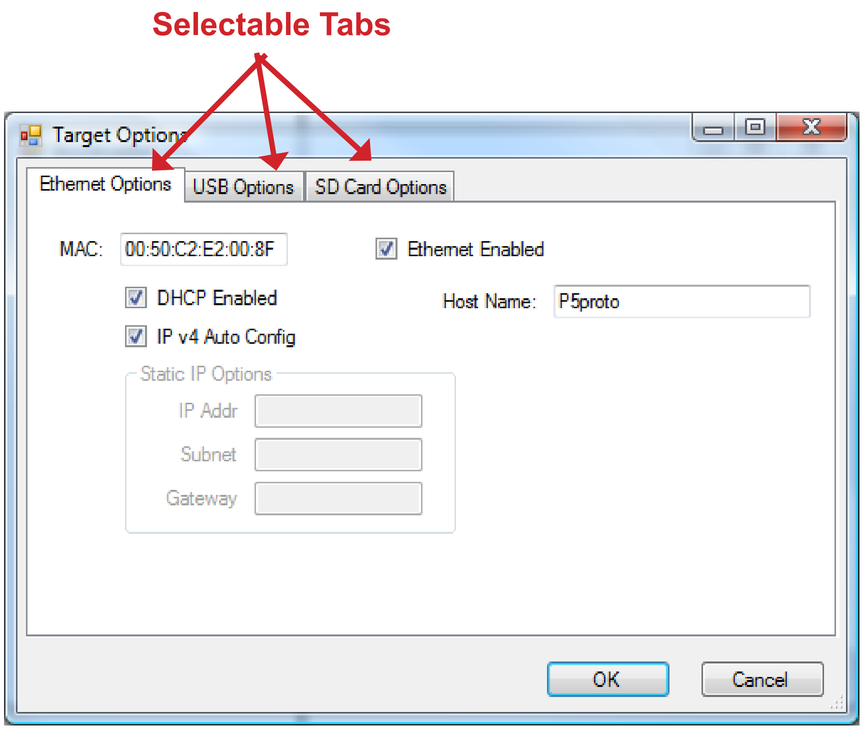
The Target Options dialog has three tabs: Ethernet Options, USB Options and SD Card Options. These items are additional configurations that are required if using any of these features on your target. See Figure 4-9.

For details on the Ethernet settings and port use, see **Chapter 19 - Ethernet**. This dialog displays information regarding the Ethernet configuration including MAC Address, etc and provides user configuration items such as Host Name and DCHP settings.

For details on the USB Options settings and use, see **Chapter 27 - USB Support**.

For details on the SD Card Options settings and use, see **Chapter 20 - SD Card Support**.

When all the configurations required have been completed, click OK to close the Target Options dialog. This will save these options. Click the RESTART TARGET button to restart the target and close the Bootloader dialog.



MAC: 00:50:C2:E2:00:8F
☑ Ethernet Enabled
☑ DHCP Enabled
Host Name: P5proto
☑ IP v4 Auto Config
Static IP Options
IP Addr
Subnet
Gateway

Figure 4-9

Installing Target Devices / Features

For greater flexibility, some target features and devices are not automatically installed on the actual hardware target when the target is selected as previously shown. Devices / Features automatically installed is entirely dependent upon the actual target selected. The P-Series PLC on a Chip™ for example only installs very minimum features while the HEC-P5XXX controller installs some features and devices, but leaves others to the actual user to install and configure.

For devices and features that are not automatically installed, they must be installed manually. The following steps are shown as basics for installing additiona devices and features. These are general steps only and some variances will occur based on the target and devices to be installed.

To select the target, either try to place a ladder diagram object in the workspace or use the **Project Menu** and click **Settings.** The Project Settings Window / Dialog box will open. Figure 4-1 is an example of the Project Settings Window and identifies the main components of it.

Select (highlight) the target and click the PROPERTIES button. The *XXXX (XXX represents the target) Target Properties* window will open. Using the *DCPN drop down menu*, select the model number of the target (if available). Refer to Figure 4.10.

This window consists of an Installed Devices pane, DCPN drop down menu and four buttons used to configure devices.

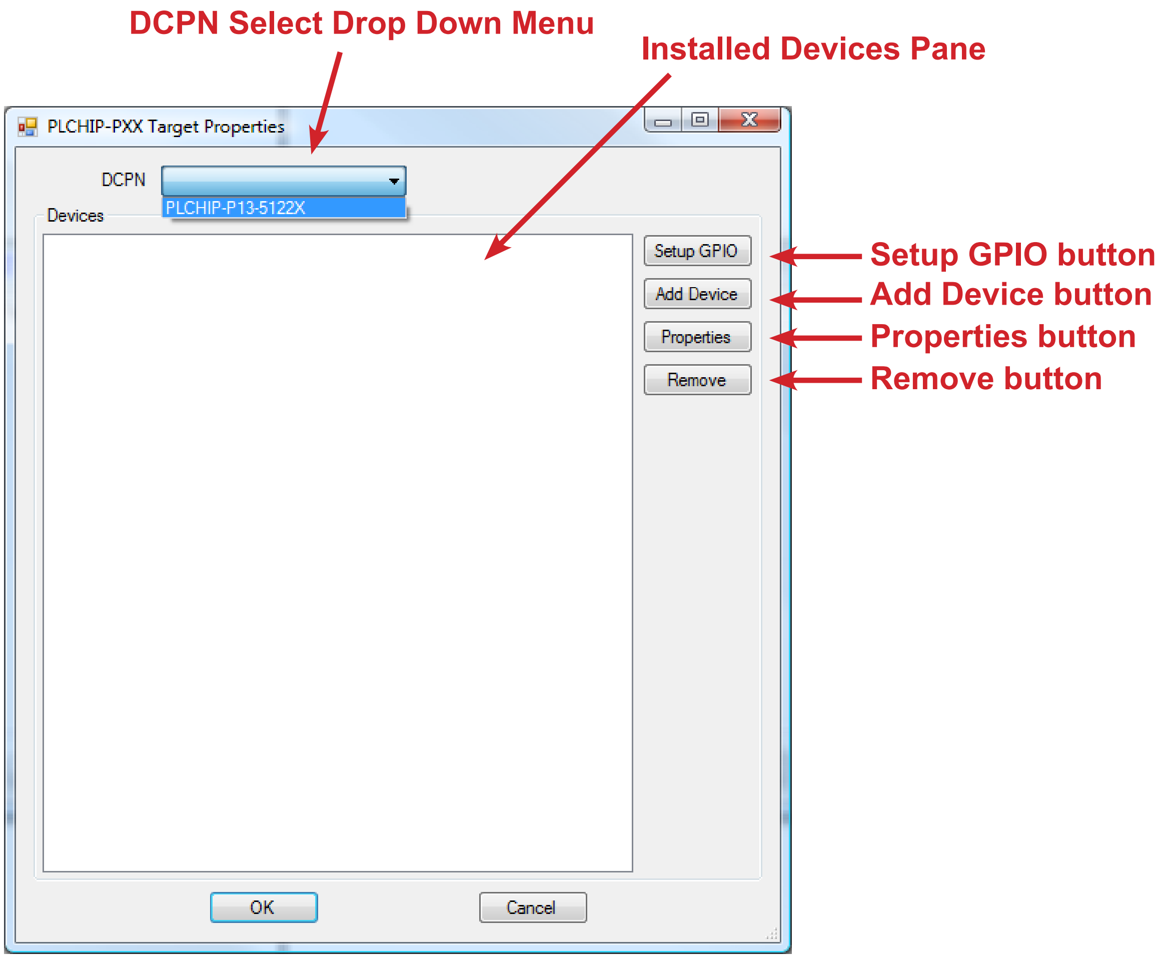


Figure 4-10

The Devices Pane shows all the currently installed devices and features for the target. Add new devices are added or devices are removed, this pane will update accordingly.

Setup GPIO

The **SETUP GPIO** button is used to add / remove General Purpose I/O (GPIO), also known as digital inputs and digital outputs. Any digital I/O to be used in the ladder diagram program must be installed in the target's devices. To configure the digital I/O (GPIO), click the **SETUP GPIO** button. The targets GPIO window / dialog box will open. Refer to Figure 4.11.

GPIO does not appear in the Devices pane when installed.

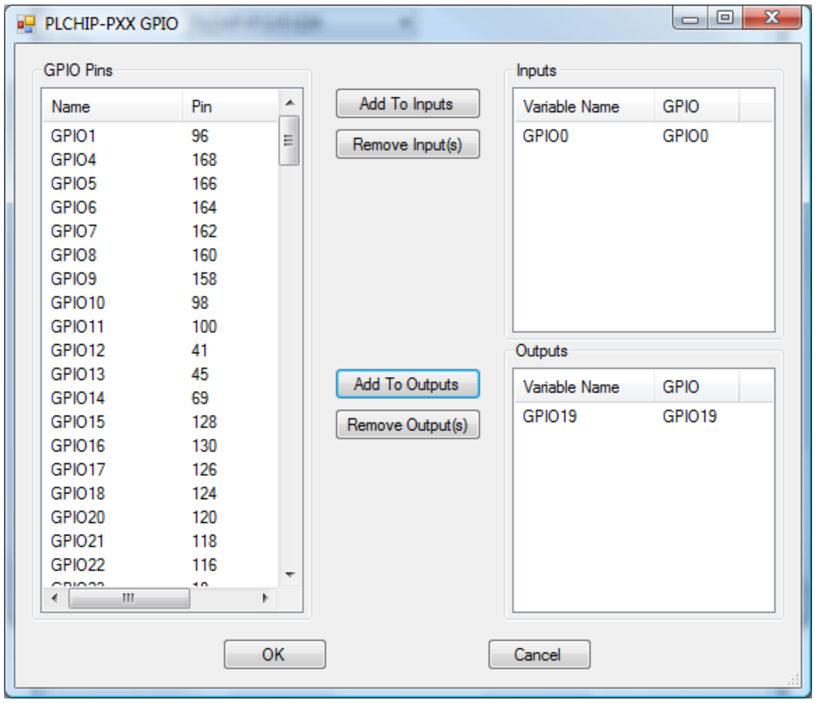
To install digital inputs, select *GPIO Pins* (listed by name and actual PLC on a Chip pin) that are required and click the **ADD TO INPUTS** button. These GPIO pins will move from the *GPIO Pins pane* to the *Inputs Pane*. If Inputs were added incorrectly or need to be removed, select them in the *Inputs pane* and click the **REMOVE FROM INPUT(S)** button.

To install digital outputs, select *GPIO Pins* (listed by name and actual PLC on a Chip pin) that are required and click the **ADD TO OUTPUTS** button. These GPIO pins will move from the *GPIO Pins pane* to the *Outputs Pane*. If Outputs were added incorrectly or need to be removed, select them in the *Outputs pane* and click the **REMOVE FROM OUTPUT(S)** button.

When all the GPIO have been installed, click the **OK** button to save the settings and close the dialog / window.

GPIO pins are designed to be configured as Inputs or as Outputs, but cannot be both simulteanously. Based on the Target selected, there may be no GPIO configuration available.

When PWM (Pulse Width Modulator) is configured, the GPIO pins associated with it are not available as GPIO as they are used as PWM. GPIO pins can only be used as either Outputs or PWM, not both simulatenously in the same program.



Name	Pin
GPIO1	96
GPIO4	168
GPIO5	166
GPIO6	164
GPIO7	162
GPIO8	160
GPIO9	158
GPIO10	98
GPIO11	100
GPIO12	41
GPIO13	45
GPIO14	69
GPIO15	128
GPIO16	130
GPIO17	126
GPIO18	124
GPIO20	120
GPIO21	118
GPIO22	116

Inputs

Variable Name	GPIO
GPIO0	GPIO0

Outputs

Variable Name	GPIO
GPIO19	GPIO19

Figure 4-11

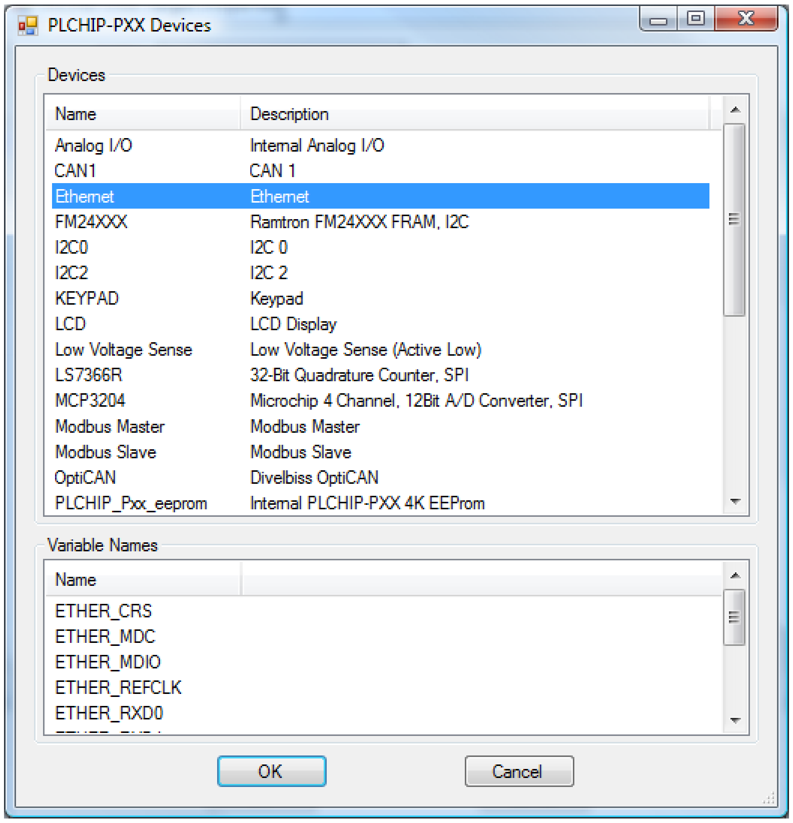
Adding Devices

The **ADD DEVICE** button is used to add / remove devices such as serial ports, Ethernet, Quadrature Inputs, etc. Any device to be used in the ladder diagram program must be installed in the target's devices. To add ad device, click the **ADD DEVICE** button. The targets Devices window / dialog box will open. Refer to Figure 4.12.

All supported devices are shown for the target.

The window / dialog is divided into two panes, *Devices* and *Variable Names*. As devices are selected, the associated variables that will be installed with them are shown in the *Variable Names pane*. Select a device from the *Devices pane* by clicking on the Name (highlight) and click **OK** to install it.

Depending upon the device, additional dialog boxes may appear with addtional configuration items that are required for the device before it can operate. Select the appropriate information for these dialog boxes. Additional support is given in later chapters that are specifically written for some devices such as Ethernet, etc.



Name	Description
Analog I/O	Internal Analog I/O
CAN1	CAN 1
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm

Name
ETHER_CRS
ETHER_MDC
ETHER_MDIO
ETHER_REFCLK
ETHER_RXD0

Figure 4-12

Some device may be required to be installed prior other devices. For example, before Modbus Slave can be installed, ether the Ethernet or a Serial Port (UART) must be installed prevously as when installing the Modbus Slave, the port must be selected. This is only an example, other situations exist similar to this. Other examples may be adding the I2C port before a FM24XXX FRAM, etc.

When PWM (Pulse Width Modulator) is configured, the GPIO pins associated with it are not available as GPIO as they are used as PWM. GPIO pins can only be used as either Outputs or PWM, not both simulatenously in the same program.

Figure 4-13 is the Target Properties Window with some devices installed. When all the devices required have been configured, click **OK** to save the settings and close the window. Be sure to save the ladder diagram program after making target changes.

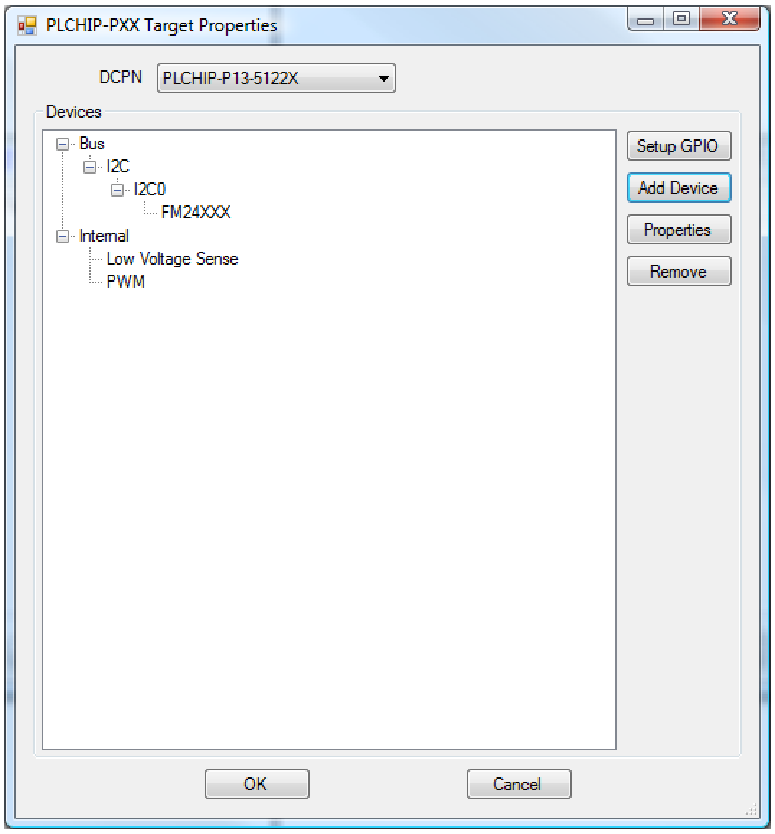

PLCHIP-PXX Target Properties
DCPN
PLCHIP-P13-5122X
Devices
Bus
I2C
I2C0
FM24XXX
Internal
Low Voltage Sense
PWM
Setup GPIO
Add Device
Properties
Remove
OK
Cancel

Figure 4-13

CHAPTER 5

Creating Ladder Diagram Projects

This chapter provides basic information and understanding to create ladder diagram projects using EZ LADDER Toolkit including variables, variable types, inserting variables, inserting objects and functions, bit addressable variables, drawing links, inserting and deleting rungs, saving ladder diagram projects and verifying and compiling ladder diagram projects.

Chapter Contents

Creating Ladder Diagram Projects

When EZ LADDER Toolkit is opened, it will automatically create a *new* blank project and it's corresponding workspace as shown in Figure 5-1. A new project may be created at any time by choosing **New** from the **File** menu.

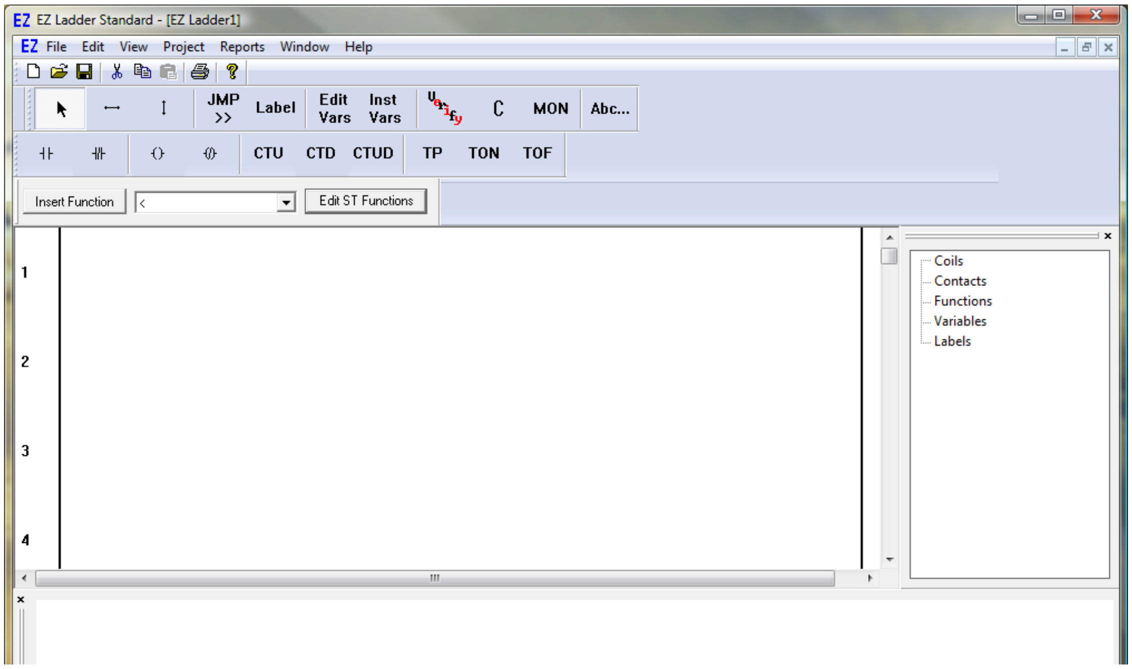


Figure 5-1

Before adding any objects, functions or variables to the new workspace, the Target must be selected and configured according to the target needs and your program requirements. Select your target by choosing **Settings** from the **Project** menu. See **Chapter 4 - Configuring Targets** and **Chapter 23 - Hardware Targets** for details.

When configuring your target, it is recommended to only install and configure features that are intended to be used. Installing unused features may degrade target performance.

Understanding Objects & Variables

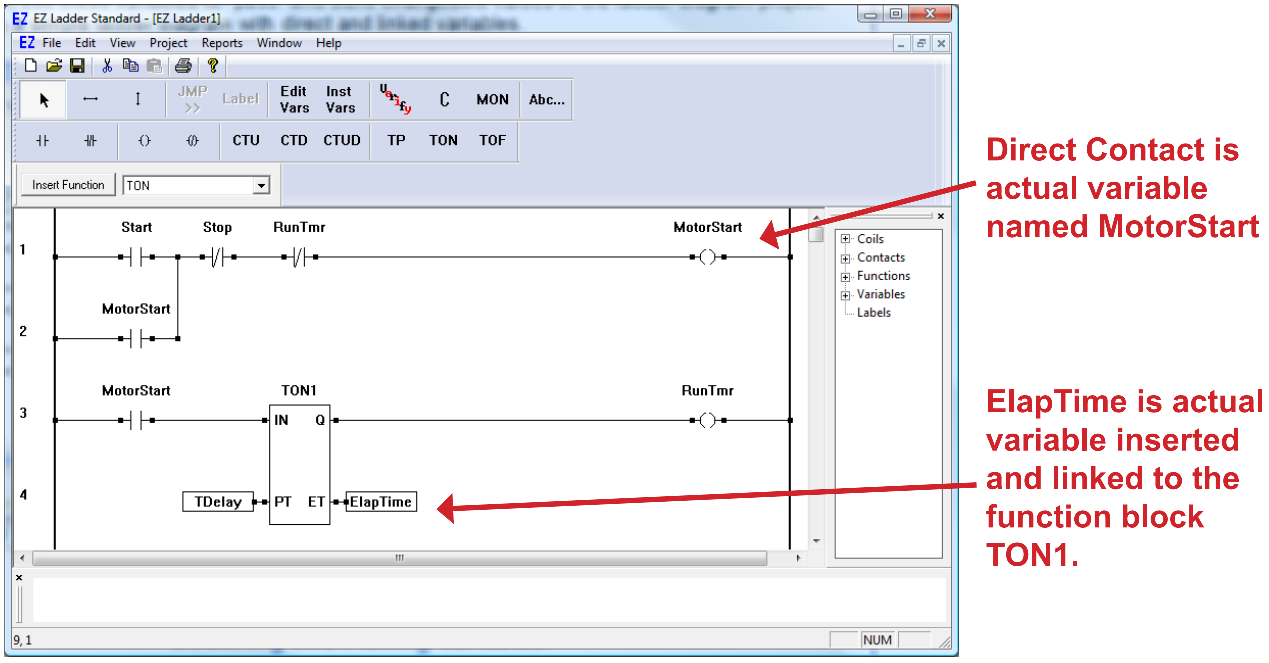
Ladder diagram projects in EZ LADDER Toolkit are comprised of a combination of objects, function blocks, variables and links. It is important to understand the basic relation of these items. These items will be covered first generally, then in more detail as this chapter progresses.

Nearly all ladder diagram objects and function blocks rely on variables, either as a definition for the object or addition to the function block to provide required data to function properly. A variable is a placeholder that represents values that *can* change. A variable can represent any number depending upon its type.

Variables are an important part of understanding how EZ LADDER uses functions and objects. Some objects, such as Direct Contacts or Direct Coils are actually defined as variables themselves while other function blocks such as TON will require variables created, inserted and connected, using links, to the function block itself to provide set points and other functional requirements.

Variables in the EZ LADDER Toolkit are global, meaning that each variable must be uniquely named and can be changed or used anywhere in the ladder diagram project.

Using function blocks, variables can *pass* data (copy or move) to other variables, functions and objects. Figure 5-2 illustrates a simple ladder diagram project that contains objects that are variables and inserted variables linked to function blocks.



EZ Ladder Standard - [EZ Ladder1]
File Edit View Project Reports Window Help
JMP Label Edit Vars Inst Vars C MON Abc...
CTU CTD CTUD TP TON TOF
Insert Function TON
Start
Stop
RunTmr
MotorStart
MotorStart
MotorStart
TON1
RunTmr
IN Q
TDelay PT ET ElapTime
Coils Contacts Functions Variables Labels
9, 1 NUM
Direct Contact is actual variable named MotorStart
ElapTime is actual variable inserted and linked to the function block TON1.

Figure 5-2

Figure 5-2 identifies the two typical ways variables are used in an EZ LADDER Toolkit ladder diagram project. As shown, the On-Delay timer function block identified as TON1 uses two unique variables (one for the set point - PT and one for the elapsed time - ET). All contacts and coils are actually variables themselves and as they are created, they must be either assigned to an existing variable or a new variable created must be created (declared) for them.

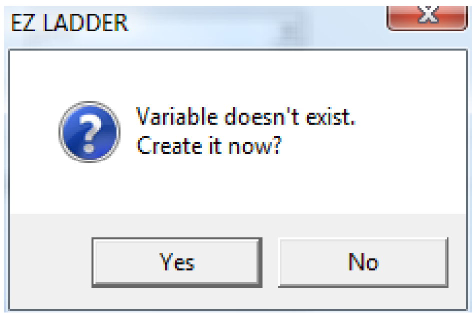
Creating and Placing Variables

Placing and creating variables can be done several ways. Inserting some objects automatically require the selection or creation of a new variable when being inserted (an automatic dialog box), while function blocks typically require you to insert any needed variables and link them without being prompted to do so.

We will identify how to create and assign variables using two methods, although variable creation is basically the same for all methods.

Placing Contacts and Coil Type Objects

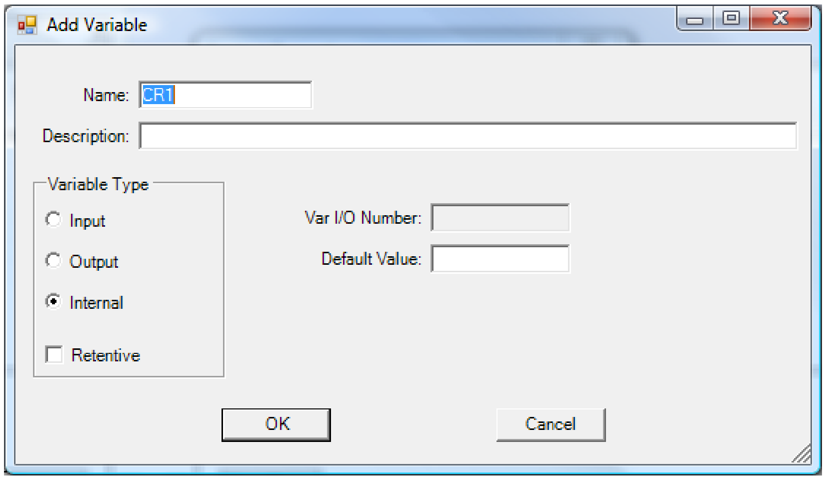
To place a contact, from the tool bar, select the Direct Contact and locate a point in the workspace to place the item. Clicking that location will place the object. When placing certain objects (coils and contacts), a ***Contact Properties*** dialog box will appear. You can choose a variable that already exists from the drop-down list or type in a new name. For this example, we will type in a new name and click **OK**. If you had selected a name that already exists, the object placement would be completed. Since we have chosen a new variable, the dialog in Figure 5-3 will appear.


EZ LADDER

Variable doesn't exist.
Create it now?

Figure 5-3

Click **YES** to create the new variable. The Add Variable dialog box will open automatically with the variable name you entered already in the Name field. See Figure 5-4. For now click **OK** to create the variable. We will cover the details of variable attributes later in this chapter. You have now successfully created a contact with a new variable. Repeat the same as needed for new contacts or coils.


Add Variable

Name: CR1
Description:

Variable Type
- Input
- Output
- [✓ Internal]
- Retentive

Var I/O Number:
Default Value:

Figure 5-4

Placing a Linked Variable

To place a variable that is linked to a function block, from the tool bar, select the Insert Variables button (Inst Vars). In the ladder diagram workspace, click in an open area and the **Variables** window will open. This window contains tabs at the top for all variable types supported.

When inserting a variable next to a function block input, only the variable types supported by the function block will be displayed as tabs in the **Variables** window.

Select the appropriate type for the variable you are needing to insert and click the ADD button. The Add Variable dialog box will open automatically. Enter a variable name in the Name field. See Figure 5-4. For now click OK to create the variable. We will cover the details of variable attributes later in this chapter. You have now placed a linkable variable.

If the variable you need to insert already exists, select it from the list and click OK to insert it.

Variables names must always begin with a letter and cannot contain spaces. Trying to begin variables with numbers or using spaces will result in a error message being displayed.

Variables may be created at any time without inserting or placing them in the ladder diagram workspace. To create a variable without placing it, from the tool bar, select the Edit Variables button (Edit Vars). The Variables window will open as shown previously. Use the ADD button to create variables as needed.

When function blocks are used with variables, as previously covered, only supported variable types are allowed. Typically, most function blocks will lock the types of variables linked to it's outputs as the same type linked to it's inputs. When changing variable types that are an input or an output to a function block, delete the variables and function block. Then insert the function block and new variables to remove all the variable type associations that previously existed.

Variable Types

There are four variable types supported in the EZ LADDER Toolkit. They are: Boolean (BOOL), REAL, INTEGER and TIMER. Each type of variable exists for specific purposes and each has pros and cons depending upon the ladder diagram project needs.

Examples of Variables:

Boolean:	0 or 1, False or True, Off or On
Real:	234.56, 192.345
Integer:	1, 525, 1034
Timer:	Days, Hours, Minutes, Seconds, Milliseconds

Boolean Variables

Boolean variables are based on only being in one of two states, typically either true or false (1 or 0, On or Off). Boolean variables are most commonly used for contacts and coils, but also may be used with function blocks as individual bits. Boolean variables are 1 byte in size.

Real Variables

Real variables are based on numbers that use floating point math (use decimal points). Real variables can range from $-1.7\text{x}10^{38}$ to $1.7\text{x}10^{38}$. Real variables are typically used for calculations and with functions where decimal point accuracy is required. Real variables used with function blocks result in a slower ***Scan Time***. Real variables are 4 bytes in size.

Integer Variables

Integer variables are based on whole numbers (no decimal points) Integers can be ranged from -2147483648 to 2147483647. Integers are used when decimal points are not required. Integer result in a faster ***Scan Time*** than real variables. Integer variables Default Value can be entered in Hexadecimal format. Integer variables are 4 bytes in size.

Timer Variables

Timer variables are used in conjunction with timer function blocks to provide input set points and output elapsed time. Timer variables consist of milliseconds, seconds, minutes, hours and days. Timer variables are 4 bytes in size.

Variable Attributes

For each variable type, specific attributes will apply. For most variables, these attributes are common. While some attributes are optional such as description, others are required prior to creating the variable. When creating a new variable, it is ideal to set it's attributes with as much detail as possible.

Integer, Real and Boolean Variable Attributes

When adding new integer, real or boolean variables, refer to Figure 5-5 for the Add Variable dialog box. The following are fields (attributes) for variables. Some must be completed while others are optional.

1. **Name**: The variable *name* is entered in this field. This name will be used to identify this variable and will be the name viewed in the workspace and any cross reference and reports. All names must begin with a letter and cannot contain any spaces. A unique name is require for each variable.

2. **Description**: This is where a text based description may be entered for more clarification and details regarding this variable. Descriptions appear in reports and in many dialog boxes. This attribute is optional.

3. **Variable Type**: The variable type is selected in this box. The choices are:

Input:	Select Input if the variable will actually represent a real world digital input on the target. Selecting this option will require that physical address of the input to be entered in the Var I/O Number field.
Output:	Select Output if the variable will actually represent a real world digital output on the target. Selecting this option will require that physical address of the output to be entered in the Var I/O Number field.
Internal:	Select Internal if the variable has no real world connection but is to be used internal in the ladder diagram project only.
Retentive:	This check box is used to identify retentive variables (variables that will store their current value on power loss and reload it automatically when power is restored). This feature must be supported on the hardware target.

4. **Var I/O Number**: This is where the physical address of real world I/O points is entered. This field is only used if the Variable Type is either Input or Output.

5. **Default Value**: This is where default variable values are set. An internal variable will be equal to this value unless it has been altered by the ladder diagram. This is used to preset values in the ladder diagram for comparisons as well as other uses. This field is optional.

6. **Address Register**: When the ladder diagram project is configured to use register based communications such as Modbus or OptiCAN, the register assignment for the variable is configured in this field. If left blank, there is no assigned register. This field only appears if a feature that will use a register is installed or supported on the hardware target and Projects Settings. This field is optional. Clicking the EDIT button opens an additional dialog box with all the available networks and makes assigning registers easier.

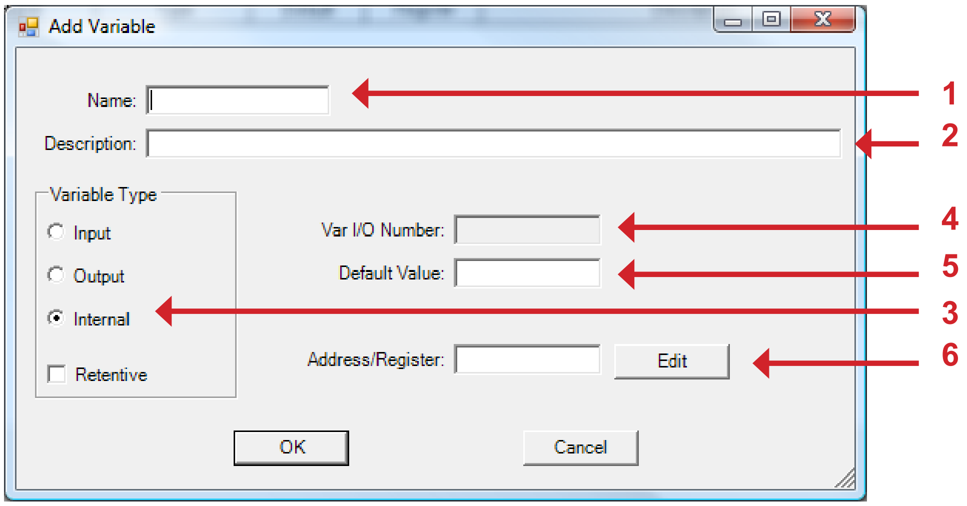


Figure 5-5

Timer Variable Attributes

When adding new timer variables, refer to Figure 5-6 for the Add Variable dialog box. The following are fields (attributes) for timer variables. Some must be completed while others are optional. Typically, time durations are entered as the unit of measure closes to the set point.

Larger times may be entered into fields provided that the total timer value does not exceed 24 days. For example, 1000 ms may be entered and will be considered 1 second when the program executes. However, if 750 hours is entered, the time is greater than 24 days and the timer will malfunction.

1. **Name**: The variable *name* is entered in this field. This name will be used to identify this variable and will be the name viewed in the workspace and any cross reference and reports. All names must begin with a letter and cannot contain any spaces. A unique name is require for each variable.

2. **Description**: This is where a text based description may be entered for more clarification and details regarding this variable. Descriptions appear in reports and in many dialog boxes. This attribute is optional.

3. **Days**: The time duration in number of days.

4. **Hours**: The time duration in hours.

5. **Minutes**: The time duration is minutes.

6. **Seconds**: The time duration in seconds.

7. **Milliseconds** The time duration in milliseconds. The millisecond resolution is target specific and is shown in parenthesis.

8. **Retentive**: This check box is used to identify retentive variables (variables that will store their current value on power loss and reload it automatically when power is restored). This feature must be supported on the hardware target.

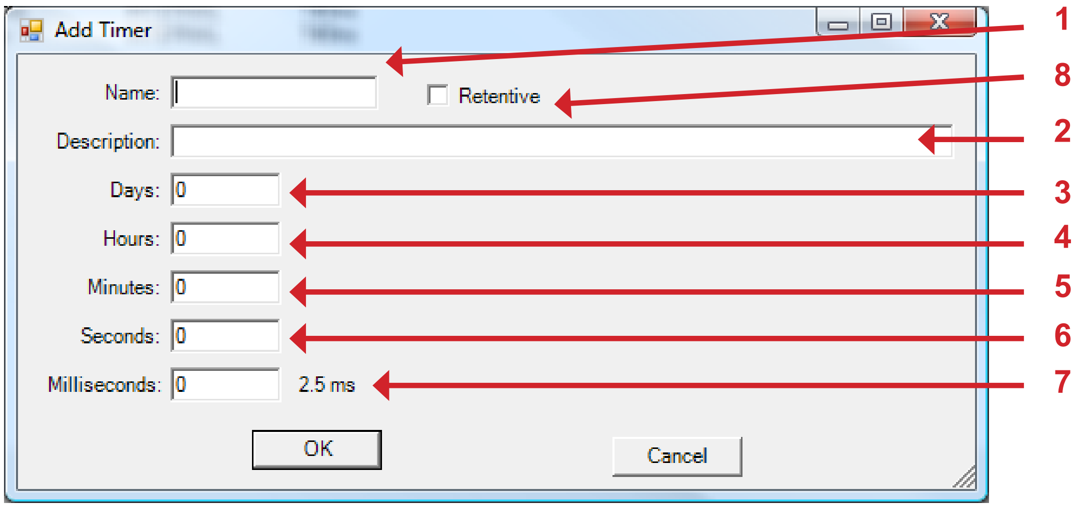


Figure 5-6

Keeping Variable Values on Power Loss

In the event of a power loss to the target, EZ LADDER Toolkit is designed to allow ladder diagram variables to be stored and then be reloaded when power is restored. This is called the Retentive feature and variables must be configured as retentive as well as the hardware target must support this feature. See **Chapter 7 - Retentive Variables** for more details on the retentive feature.

Placing Objects and Drawing Links

To place an object in an EZ LADDER Toolkit project, select the object or function block from the tool bar or select the object or function block from the tool bar drop down menu. Position the pointer in the ladder diagram workspace where the object is to be inserted and left-click. This *places* the object at that point. As you add objects, variables may need created. See earlier in this chapter for how to create variables.

Figure 5-7 illustrates the placement of a Direct Contact and Direct Coil. Please refer to **Chapter 24 - Function Reference**.

The last placed object stays selected until a different object or button in the tool bar is chosen. This feature allows an object be placed multiple times without the need of re-selecting the object.

To place an object or function, there must be enough space in the ladder diagram workspace at the point of insertion. If there is insufficient space, an error message will display.

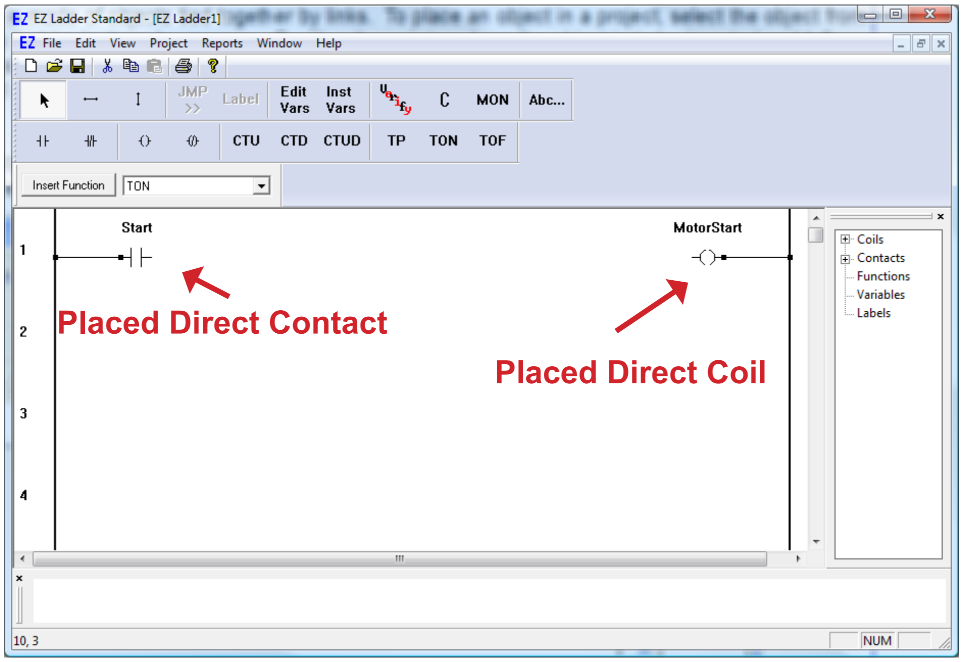


Figure 5-7

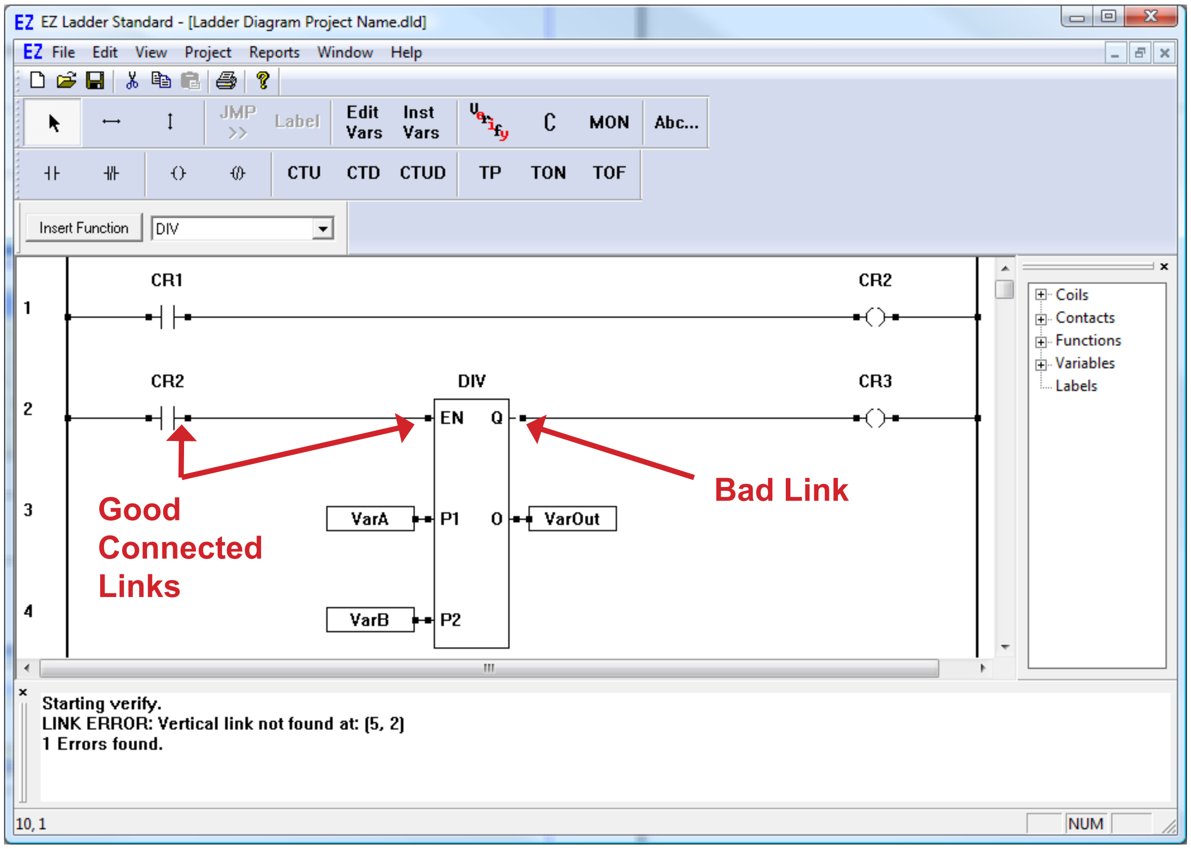
Refer to Figure 5-7, note when placing objects near the left or right power rails, links are automatically drawn to the power rails. This also applies when variables are inserted next to functions; the links are automatically drawn from the inserted variable to the function.

To finish the circuit shown in Figure 5-7, it will be necessary to draw a horizontal link between the contact and coil on rung 1. Select the Horizontal Link Tool from the tool bar. Refer to **Chapter 2 - Navigating EZ LADDER Toolkit** for details on tool bars and buttons.

To draw the link, click and hold the click at the location where the link will start, at the right side of the contact on rung 1. Holding the mouse button down (clicked), drag the pointer to the left side of the coil on rung 1. When the link is drawn connecting both objects, release the mouse button to complete the link.

If a vertical links are required (as in parallel circuits), select the Vertical Link Tool from the tool bar. Using the same method, click and drag until a vertical link is created.

Horizontal and Vertical links snap to grid locations and can only be started and stopped at one of these locations. Take care when connecting links to objects and function blocks that the link actually connects to the block and not just near it. If a link does not connect, then an error will occur when Verifying or Compiling the ladder diagram project. Figure 5-8 shows a connected link and a link that is not connected.



```
Starting verify.
LINK ERROR: Vertical link not found at: (5, 2)
1 Errors found.
```

Figure 5-8

When connecting two function blocks in series, where a variable output of the first needs to be connected to the second function blocks variable input, you must insert a variable between them. Failure to place a variable between function blocks (variable inputs and outputs only) will result in the ladder diagram project Compiling successfully, but it will not operate as intended.

Using Copy and Paste

EZ LADDER Toolkit, being a Windows based application, allows the copy and paste functions inherit to Windows with certain limitations imposed. It is possible to copy any single or combination of objects, function blocks, variables and links to the Windows Clipboard.

To Copy object(s), choose the Select Tool from the tool bar. To choose a single object, left click on the object to select it. To select multiple objects, click and drag across the objects. Objects may be selected by hold-ing the CTRL key while clicking on them. With the items selected, using the **Edit Menu**, choose **Copy** or right-click and choose **Copy**. The objects are now copies to the Windows Clipboard.

Unlike a standard windows application, objects on the clipboard cannot be pasted using CTRL-V or by using the **Edit Menu's Paste** feature. To paste an object or multiple objects in EZ LADDER Toolkit, use the Select Tool from the tool bar and hover the point at the location to paste (if pasting multiple objects, this would be the top, left of the objects that will be pasted). Right-click and choose **Paste**. The objects will be pasted.

! When pasting objects or rungs, there must be enough room to paste the copied section (horizontally and vertically) or an error will occur. When pasting rungs, move the pointer near the left power rail as an pasting point.

Inserting and Deleting Rungs

During development of a ladder diagram project, it often becomes necessary to insert new rungs between existing rungs or to delete rungs that will not be required.

Inserting Rungs

To insert a new rung in EZ LADDER Toolkit, position the pointer where the insertion needs to occur (typically near the left power rail). Right-click and choose **Insert Rung**. A rung will insert at this location. All later rungs will be moved accordingly and all cross references will update with the new rung numbers.

Deleting Rungs

To delete a rung, position the pointer on the rung to be deleted. Right-click and choose **Delete Rung**. The selected rung will be deleted. Only empty rungs may be deleted.

Saving EZ LADDER Toolkit Projects

Saving an open ladder diagram project can be done two ways. Click the Save button on the tool bar or use the **File Menu**, and choose **Save**. If the project has not been previously saved, a dialog box will appear to enter name and save the project. The **Save As** selection in the **File Menu** always provides a dialog box for naming the project.

Verifying and Compiling Ladder Diagrams

After a ladder diagram has been created, it must be *verified* and *compiled* prior to downloading it to an actual hardware target. This process checks the ladder diagram for adherence to all EZ LADDER Toolkit and target rules and then creates a file that will be downloaded to the hardware target. This file, while maintaining the functionality of the ladder diagram actually has no graphical representation and is generally not recognizable or viewable.

To Verify a Project

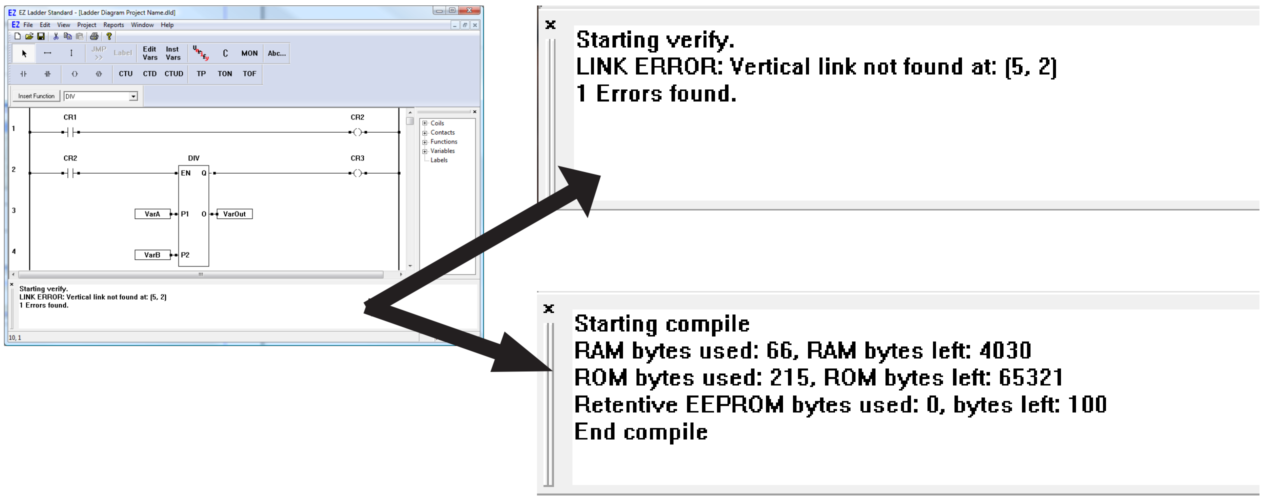
The verification process will check the ladder diagram for completeness and common rules, verifying there are not broken links, etc. To verify the ladder diagram project, on the tool bar, click the Verify button. In the Output Window at the bottom, a message will be displayed with the status and results of the verification process.

To Compile a Project

The compilation process involves two actions. The first is an automatic verification is done and if no problems are detected, the ladder diagram is then compiled (converted into machine language code for downloading to the hardware target). To compile a ladder diagram project, on the tool bar, click the Compile button.

All EZ LADDER Toolkit Projects must be compiled prior to downloading them to a hardware target. Once a program has been compiled, it does not need to be compiled again unless the actual ladder diagram project has changed since it was last compiled.

Any errors encountered during the compilation process must be corrected before the compilation will successfully complete and provide operational compiled code. See **Chapter 22 - Troubleshooting** for common error messages. Figure 5-9 illustrates two Output Window messages for the same ladder diagram project. The first identifies errors during the compile process while the second illustrates a successful compile.



```
Starting verify.
LINK ERROR: Vertical link not found at: (5, 2)
1 Errors found.
```

```
Starting compile
RAM bytes used: 66, RAM bytes left: 4030
ROM bytes used: 215, ROM bytes left: 65321
Retentive EEPROM bytes used: 0, bytes left: 100
End compile
```

Figure 5-9

Bit Addressable Variables

As covered earlier in this chapter, variables are an important part of an EZ LADDER Toolkit project. While most projects will use variables as described earlier, the EZ LADDER Toolkit also provides a feature to use integer variables and then actually control the individual bits that make up the entire integer variable (number, total of 32 bits per integer). This feature is called Bit Addressable Variables.

Any integer may be used as a bit addressable variable. As a bit addressable variable, each variable has 32 individual bits that are numbered 0-31 and each bit represents the *binary* bit of the total integer variable number. To understand bit addressable variables, you must have a basic understanding of the binary numbering system where numbers are created using ones and zeros in specific placeholder bits that represent an actual number.

$$\begin{tikzcd}
\text{Bit Number (0-31):} & 6 \arrow[d] & 5 \arrow[d] & 4 \arrow[d] & 3 \arrow[d] & 2 \arrow[d] & 1 \arrow[d] & 0 \arrow[d] & & \\
\text{Placeholder:} & 64 \arrow[d] & 32 \arrow[d] & 16 \arrow[d] & 8 \arrow[d] & 4 \arrow[d] & 2 \arrow[d] & 1 \arrow[d] & & \text{Add the placeholder numbers of bits with 1's only} \\
\text{Binary Bits:} & 0 & 0 & 0 & 1 & 1 & 0 & 1 \arrow[rr] & &
\end{tikzcd}$$

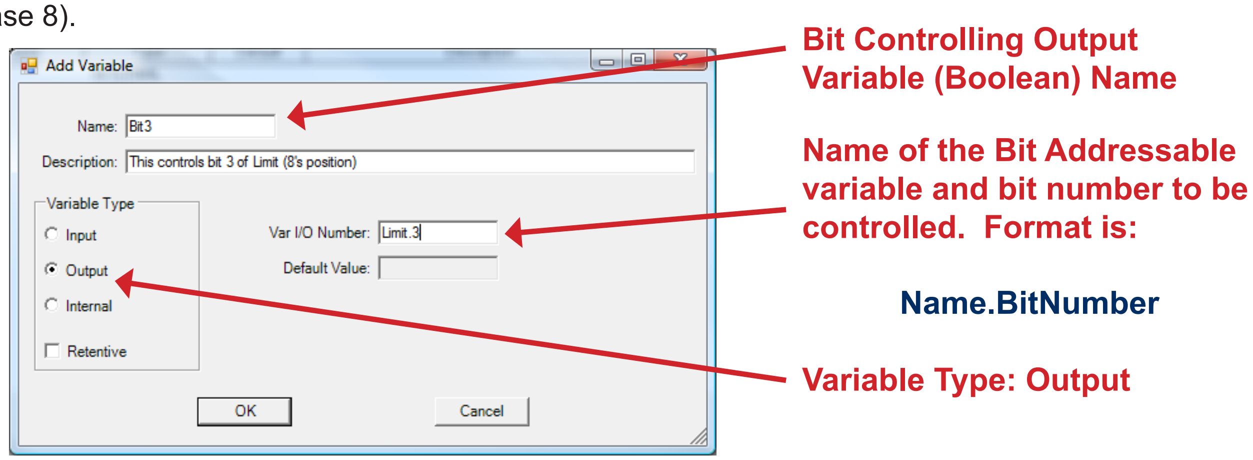
8 + 4 + 1 = 13

The integer variable value would be 13.

Setting the bit of a Variable

To set the bit of an integer variable, identify or create the variable. In addition to the variable that will be bit addressable (the one you just identified), additional variables will be required to write to the bits of the original bit addressable variable (one for each bit that you intend to use).

These additional variables will be (boolean) output variables, representing a boolean 0 or 1 for the actual bit. In Figure 5-10, the Add Variable dialog box shows the creation of one of the actual bit controlling boolean variables. These bit controlling variables are always set as Output and the Var I/O Number is the variable name of the bit addressable variable and the bit number to control separated by a period. In Figure 5-10, the bit addressable variable is named *Limit* and the bit shown being controlled is 3 or the placeholder for the number 8 in integer form and the variable that is controlling the bit is named *Bit3*. Therefore, if *Bit3* is true then bit 3 of the variable *Limit* would be true, changing the value of the variable Limit by its placeholder value (in this case 8).


Add Variable
Variable Type
Input
Output
Internal
Retentive
OK
Cancel
Bit Controlling Output Variable (Boolean) Name
Name of the Bit Addressable variable and bit number to be controlled. Format is:
Name.BitNumber
Variable Type: Output

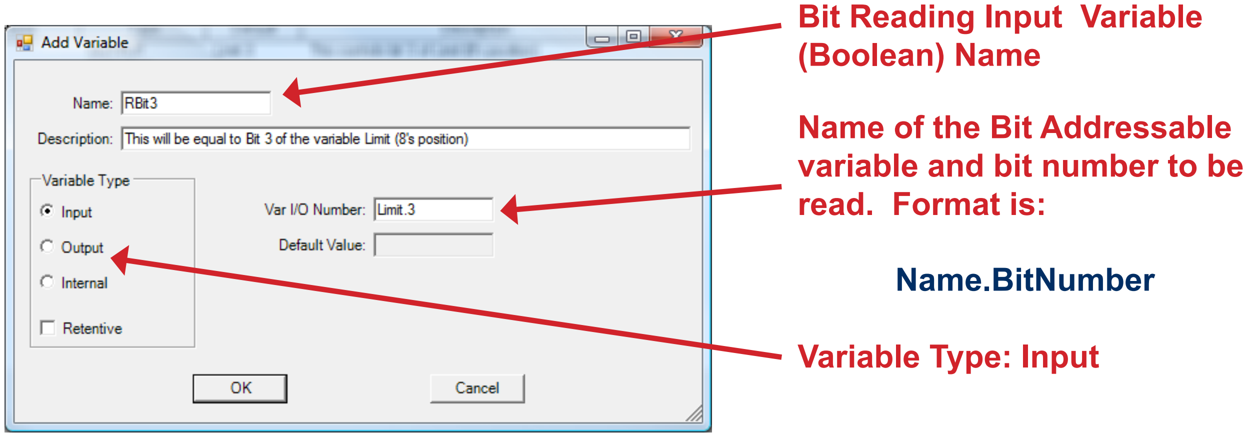
Name: Bit3
Description: This controls bit 3 of Limit (8's position)
Var I/O Number: Limit.3
Default Value:

Figure 5-10

Reading the bit of a Variable

To read the bit of an integer variable, identify or create the variable. In addition to the variable that will be bit addressable (the one you just identified), additional variables will be required to read to the bits of the original bit addressable variable (one for each bit that you intend to use).

These additional variables will be (boolean) input variables, representing a boolean 0 or 1 for the actual bit. In Figure 5-11, the Add Variable dialog box shows the creation of one of the actual bit reading boolean variables. These bit reading variables are always set as Input and the Var I/O Number is the variable name of the bit addressable variable and the bit number to read separated by a period. In Figure 5-11, the bit addressable variable is named *Limit* and the bit shown being read is 3 or the placeholder for the number 8 in integer form and the variable that is reading and storing the bit is named *RBit3*. Therefore *RBit3* will be equal to the actual binary status (0 or 1) of bit 3 of the *Limit* variable.


Add Variable
Variable Type
Input
Output
Internal
Retentive
Default Value:
OK
Cancel
Bit Reading Input Variable (Boolean) Name
Name of the Bit Addressable variable and bit number to be read. Format is:
Name.BitNumber
Variable Type: Input

Name: RBit3
Description: This will be equal to Bit 3 of the variable Limit (8's position)
Variable Type: Input
Var I/O Number: Limit.3

Figure 5-11

CHAPTER 6

Downloading and Running Projects

This chapter provides basic information needed to connect to hardware targets, download ladder diagram projects and use real-time EZ LADDER Toolkit features.

Chapter Contents

Switching Modes in EZ LADDER Toolkit

EZ LADDER Toolkit is generally has two modes of operation. Up to this point, most of the time we have been using the ***Edit Mode***. The Edit Mode is used to open and close projects, configure targets, create ladder diagram projects, verify and compile them. The ***Monitor Mode*** is used to connect to hardware targets, download ladder diagram projects, monitor their power flow in real-time and to work with target utilities. Typically switching modes is done often during ladder diagram project development.

Switching to Monitor Mode

To switch to monitor mode, on the tool bar, click the **MONITOR** button. Refer to **Chapter 2 - Navigation EZ LADDER Toolkit** for tool bar and buttons. EZ LADDER Toolkit will switch from the Edit Mode to the Monitor Mode. While the ladder diagram workspace will appear similar, some tool bars and buttons will change adding functionality for features only needed in Monitor Mode. Figure 6-1 shows EZ LADDER Toolkit in the Monitor Mode.

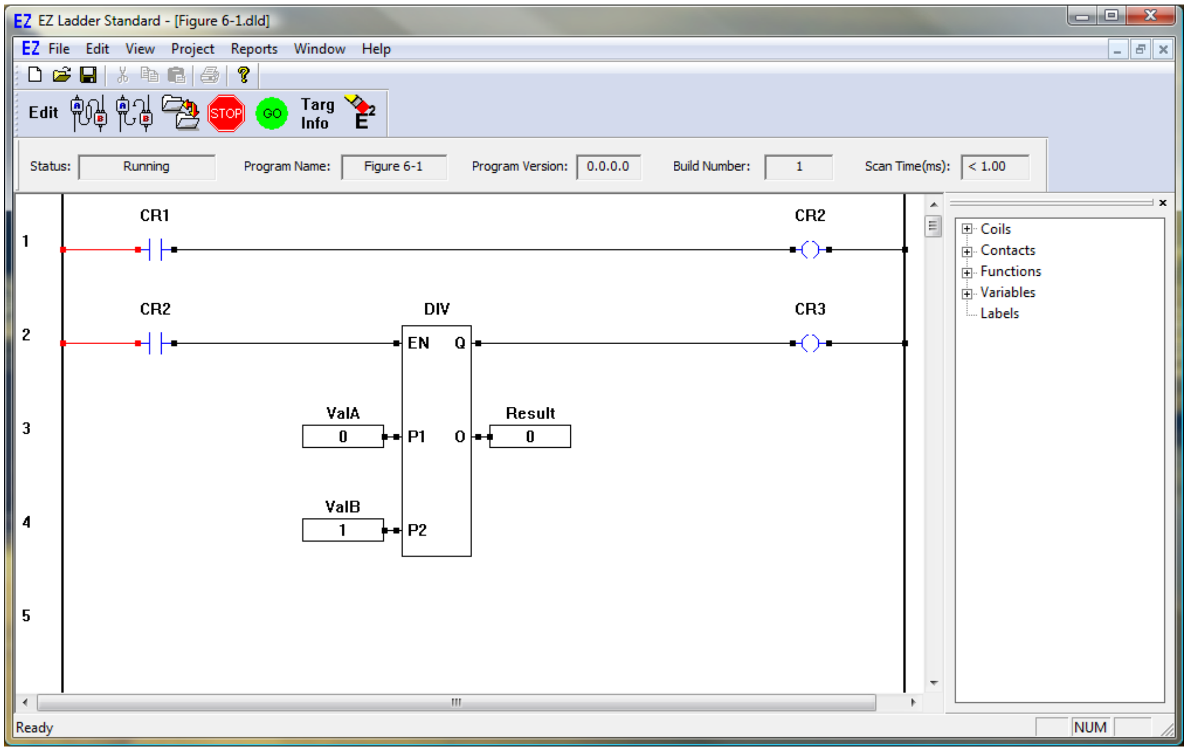


Figure 6-1

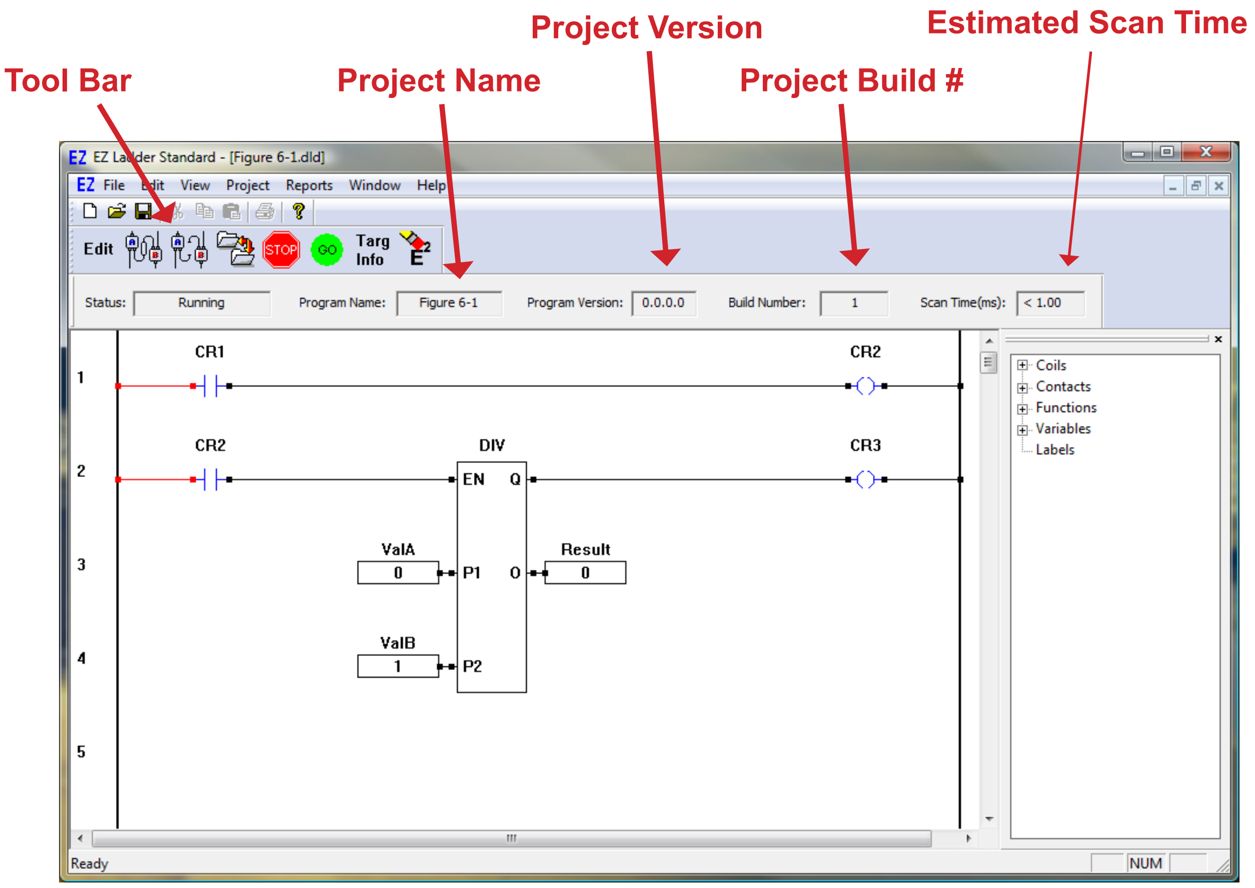
In addition to the tool bar changes, the Output Window is not available in the Monitor Mode as the program should be compiled in the Edit Mode prior to switching to the Monitor Mode.

Switching to Edit Mode

When in the Monitor Mode, to switch back to the Edit Mode, on the tool bar, click the Edit button. EZ LADDER Toolkit will switch from Monitor Mode to the Edit Mode. All Edit Modes standard tool bars, menus and windows will reappear.

Monitor Mode Overview

While the Monitor Mode generally looks similar to the Edit Mode, the tool bars, menus and windows can differ greatly. Refer to Figure 6-2 for identification status fields.



Status: Running
Program Name: Figure 6-1
Program Version: 0.0.0.0
Build Number: 1
Scan Time(ms): < 1.00

Figure 6-2

The following descriptions are for buttons found on the Monitor Mode Tool Bar.

Edit Mode. Switches EZ LADDER Toolkit to the Edit Mode.

Connect. Connects EZ LADDER Toolkit to the hardware target's Programming Port.

Disconnect. Disconnects EZ LADDER Toolkit from the hardware target..

Download. Transfers the compiled ladder diagram project to the hardware target and saves the program in memory and starts executing the program. The program will remain until over written by a new downloaded program.

Stop. Stops execution of the ladder diagram project on the hardware target.

Go. Starts execution of the ladder diagram project on the hardware target.

Target Information. Opens the a target information dialog that identifies the actual target version connected to EZ LADDER Toolkit and the current Target's Name or Model Number.

EEPROM Erase. This erases the EEPROM on the hardware target. The target must support EEPROM storage for this feature to function.

There is no UNDO when erasing the EEPROM. Once the EEPROM has been erased, all contents are lost. Take care in erasing the EEPROM as to not lose valuable data.

Connecting to a Target

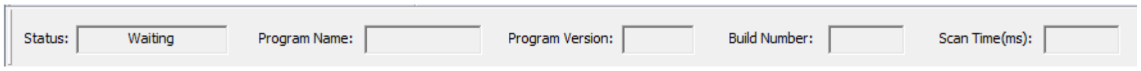
To download a ladder diagram project to a hardware target, it must first be connected to in the Monitor Mode. To successfully connect to a target, the Serial Port Settings in the Project Settings Window must match your computers setup, the appropriate programming cable must be connected from the computer's serial port to the hardware target's programming port and the hardware target must be turned on.

To connect to target, click the CONNECT button located on the tool bar. If an error occurs, check the Serial Port Settings, cable and target. Also see **Chapter 22 - Troubleshooting**.

When connecting to a target, the background of the workspace may change with watermark text identifying conditions such as when a different program is runnng than is open in EZ LADDER Toolkit.

When Target has no Project Loaded

If the target does not have a previously loaded ladder diagram project, then no dialog boxes will open when the Connect button is clicked. The Status window typically will change to *Waiting* to identify that the connection is complete and the hardware target is waiting for a ladder diagram project to be downloaded. Figure 6-3 illustrates the status as described.

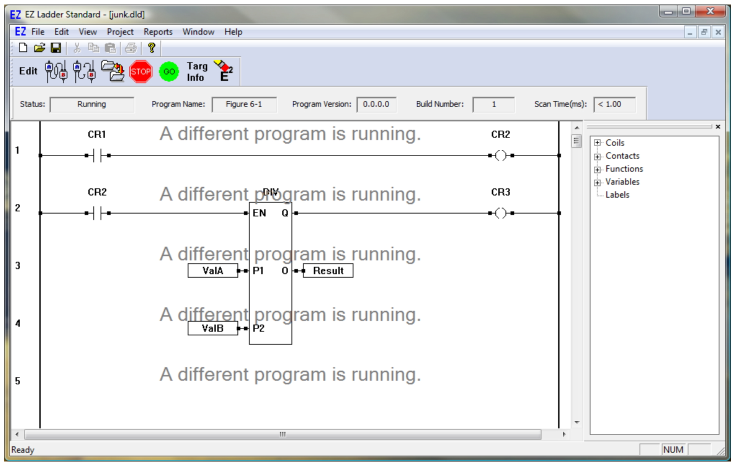


Status: Waiting Program Name: Program Version: Build Number: Scan Time(ms):

Figure 6-3

When Target has Different Project Loaded

If the ladder diagram project name of the project open in EZ LADDER Toolkit does not match the name of the ladder diagram project that is loaded on the target, workspace background will change as shown in Figure 6-4. This warning can be caused because the projects differ or the project open in EZ LADDER Toolkit was renamed or saved with a different name using the Save As since it was loaded on the target. Downloading the project will clear this watermark text shown.



EZ Ladder Standard - [junk.dld]

Status: Running Program Name: Figure 6-1 Program Version: 0.0.0.0 Build Number: 1 Scan Time(ms): < 1.00

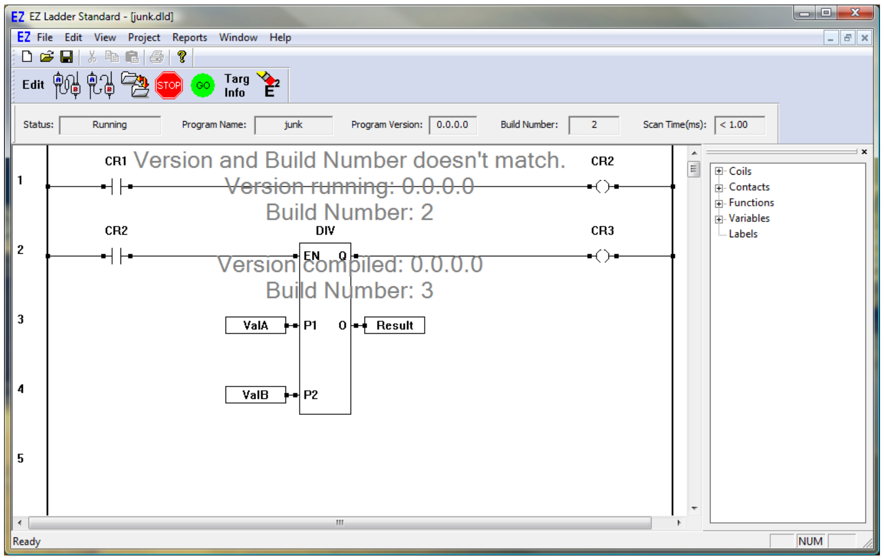
A different program is running.
A different program is running.
A different program is running.
A different program is running.
A different program is running.

Figure 6-4

When Target has the Same Project

If the ladder diagram project name of the project open in EZ LADDER Toolkit does match the name of the ladder diagram project that is loaded on the target, two results can occur. If the build number (that automatic number that increments each time a project is compiled, See **Chapter 4 - Configuring Targets**), is the same as the build number of the project loaded on the target, no dialog boxes are displayed. The Status, Program Name, Program Version, Build Number and Scan Time are updated. Now ladder diagram project can be viewed in real-time.

If the two build numbers differ, then the warning water mark test in Figure 6-5 is displayed. This text serves as a warning that the two build numbers do not match. While this is usually caused by the ladder diagram project being compiled again since it was downloaded, it also requires that you must download the new build of the ladder diagram project to view it in real-time.



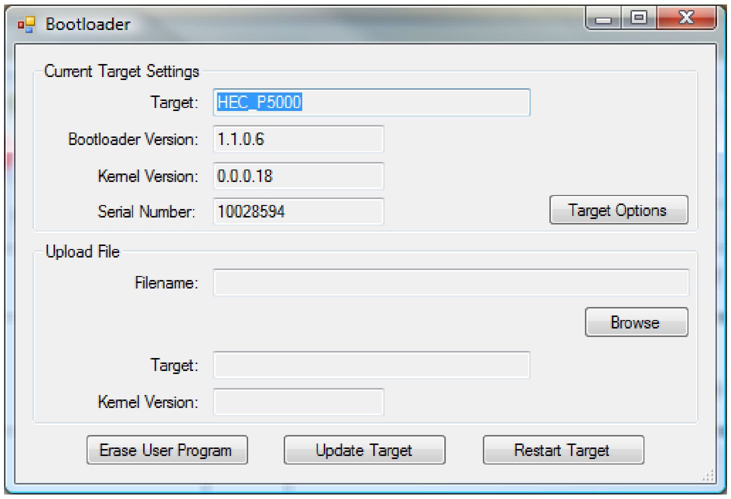
Status: Running Program Name: junk Program Version: 0.0.0.0 Build Number: 2 Scan Time(ms): < 1.00

Version and Build Number doesn't match.
Version running: 0.0.0.0
Build Number: 2
Version compiled: 0.0.0.0
Build Number: 3

Figure 6-5

Connecting for the First Time to a New Target

To connect to a target, the target must have a kernel installed. As hardware targets are shipped from the factory without kernels, the kernel must be loaded prior to being able to connect and download projects. When trying to connect to a new target for the first time (if it is configured correctly and successful), the Bootloader Window automatically is displayed. From this window, the kernel can be selected and installed on the hardware target. Figure 6-6 illustrates the Bootloader window. Refer to **Chapter 4 - Configuring Targets** for details on installing and upgrading the hardware target kernel.



Current Target Settings
Target: HEC_P5000
Bootloader Version: 1.1.0.6
Kernel Version: 0.0.0.18
Serial Number: 10028594

Upload File
Filename:
Target:
Kernel Version:

Figure 6-6

Downloading Ladder Diagram Projects to Targets

When connected to a hardware target, click the DOWNLOAD button located on the tool bar. A dialog box will temporarily be displayed showing the status of the ladder diagram's download to the target and the Status field will indicate *Downloading*.

Upon completion of the download, the Status field will update and indicate *Running*. The target has now been programmed with the ladder diagram project. A download action causes the project to download, for the project to be saved in the target's non-volatile memory and then it is given a execute command to begin running on the target.

The project is now executing on the hardware target. The status of contacts, coils, function blocks, variables and power flow may be viewed in real-time.

Disconnecting from the target or changing to Edit Mode does not stop the target from operating as it can only be stopped by removing power or the use of the Stop button in the Monitor Mode.

It is important that all ladder diagram projects be archived for safe keeping. There is no method to recover a ladder diagram project from the target. The actual ladder diagram file must be available for editing and future downloads.

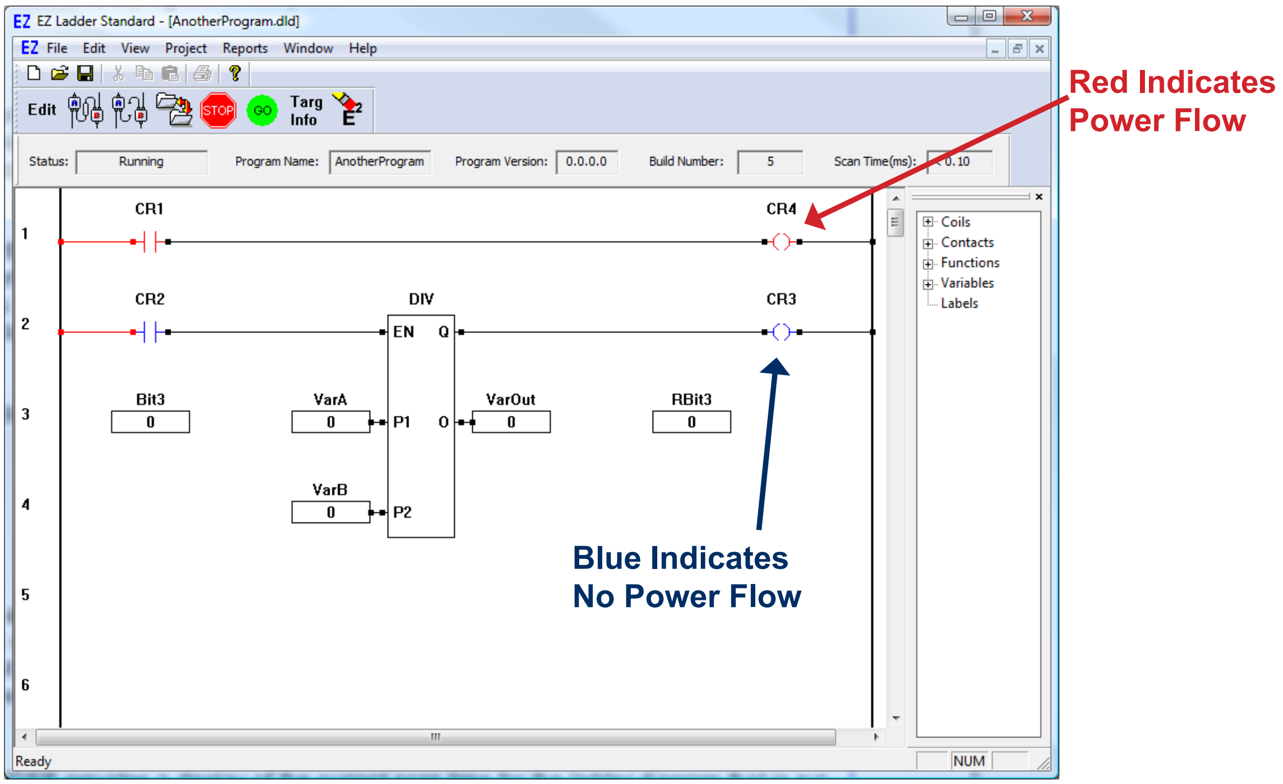
Real-Time Features

When connected to a hardware target with an executing program, there are additional real-time monitoring features available in the EZ LADDER Toolkit. These features include Power Flow indication, Scan Time, Starting and Stopping program execution, hover boxes and the ability to change variable values.

Power Flow Indication

Monitoring a project in real-time provides the ability to watch the state of contacts, coils, function blocks and variables. See Figure 6-7. Contacts and Coils are actually represented in their current state (On / Off) by color. Blue represents the contact or coil in it's rest state (un-powered state) while Red represents a powered or flow condition. As real world and internal objects change during program execution, they are represented in color accordingly and the flow of power can be viewed (Power Flow) from the left power rail to the right power rail).

Although contacts and coils change colors based on their actual state, some links may change color, but most links and all function blocks remain the standard black and white color.



Status: Running Program Name: AnotherProgram Program Version: 0.0.0.0 Build Number: 5 Scan Time(ms): < 0.10

Figure 6-7

Scan Time

Scan time is calculated in real-time, updated and displayed in the Scan Time Field. The scan time is always represented in milliseconds. The scan time resolution is target specific. For more information on scan time, please see **Chapter 3 - Ladder Diagram Basics**.

Starting and Stopping Program Execution

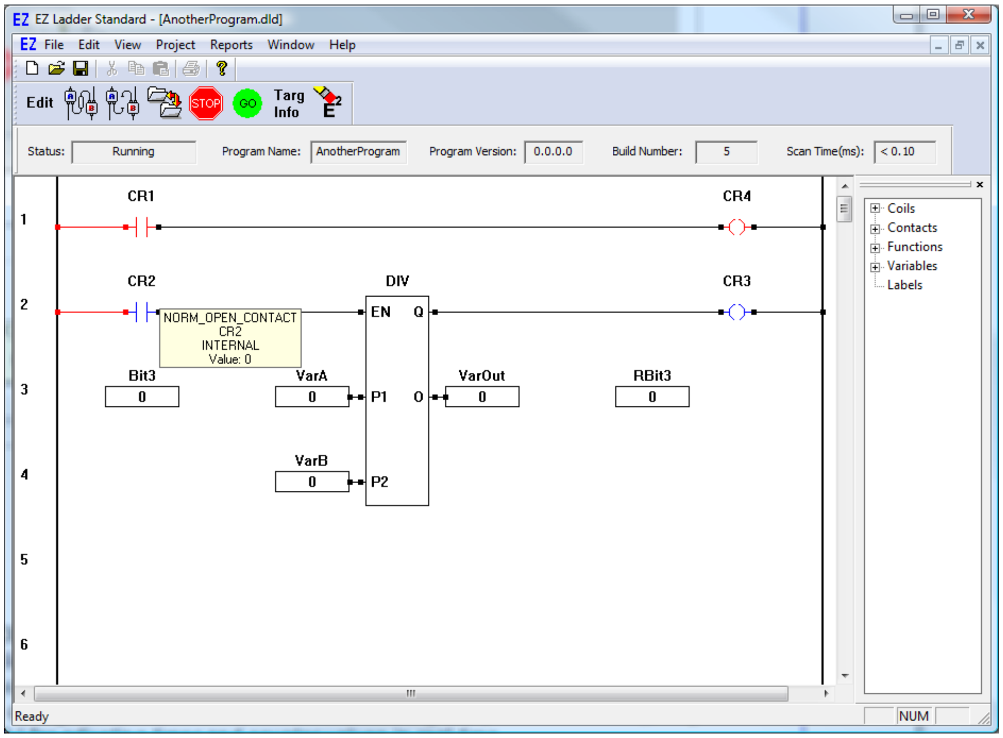
The program on the target can be stopped and started again using the EZ LADDER Toolkit when in Monitor Mode and connected to the target.

To Stop a program from executing on the target, on the tool bar, click the Stop button. This can be useful when troubleshooting and diagnosing ladder diagrams that do not operate as expected.

To Start a program executing on the target, on the tool bar, click the Go button. This can be useful when troubleshooting and diagnosing ladder diagrams that do not operate as expected.

Hover Boxes

Another useful feature that can be utilized in real-time monitoring is the use of hover boxes. When the mouse pointer is hovered over an object, a hover box will appear that provides additional information in regards to the function or object including it's name and current status. Figure 6-8 shows a typical hover box. The mouse pointer is located over the contact CR2. Notice the hover box is now shown and identifies the contact by name, type and it's current state or value.


EZ Ladder Standard - [AnotherProgram.dld]
File Edit View Project Reports Window Help
Edit STOP GO Targ Info
Coils
Contacts
Functions
Variables
Labels
Ready NUM

Status: Running Program Name: AnotherProgram Program Version: 0.0.0.0 Build Number: 5 Scan Time(ms): < 0.10

NORM_OPEN_CONTACT
CR2
INTERNAL
Value: 0

Figure 6-8

Changing Variable Values

EZ LADDER Toolkit provides an option for changing the value of a variable while the ladder project is executing. Double-click on the object and an dialog box appears with the current state or variable value. This box is changeable and the value may be changed. Change the value as needed and click OK. The changes take place immediately. The change does not affect the actual ladder diagram (in the Edit mode), only the executing program. This is helpful for adjusting timer and counter values in real time during debugging.

Changing a contact variable (boolean) does not always have the desired effect. For example: If the value of an internal coil (that is connected to a real world input) is changed using the dialog box, the actual value will change only until the next scan and then will revert to its real world status. Since all I/O status is re-evaluated each scan, the contacts and coils are updated and will override variable changes. Actual real world inputs cannot be changed at all.

Changing any variable value in real-time does not change the ladder diagram project. Changes that wish to be kept must be manually changed in the project in the Edit Mode. Additionally, any variable changes on the target are lost if the target is stopped, started or power is reset to it.

CHAPTER 7

Retentive Variables & EEPROM Memory

This chapter provides basic information to understand what Retentive variables are, when to use and how to use them including their limitations. EEPROM installation and use is also provided.

Chapter Contents

What is a Retentive Variable

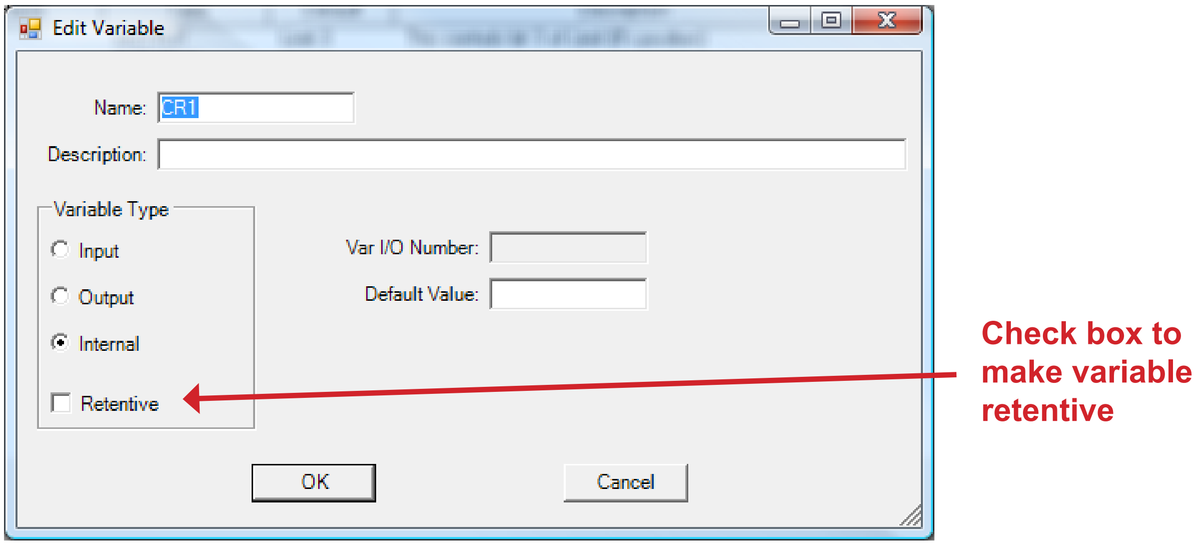
A Retentive variable is a variable that's value is automatically stored in non-volatile memory in the event of a power interruption on the hardware target. When power is restored, retentive variable values are automatically read from the non-volatile memory and re-loaded into their original variable.

Retentive variables are used often to recover from a power interruption and continue the process that is being controlled without initializing the process or wasting materials.

! The hardware target must support Retentive Variables for this feature to work. Adding retentive variables to a ladder diagram project alone does not guarantee retentive functionality.

How to Make a Variable Retentive

For a variable to be retentive, it must be identified as retentive. To identify a variable as retentive in the Edit Mode, click the Edit Vars button located on the tool bar. Select the variable that is to be retentive. Click the EDIT button. The Edit Variable dialog will appear as in Figure 7-1.



Name: CR1
Description:
Variable Type
- Input
- Output
- [✓ Internal]
- Retentive

Var I/O Number:
Default Value:

Figure 7-1

To make the variable retentive, click the Retentive check box and click OK. The variable is now retentive and will be stored in the event of a power interruption provided the actual target supports the retentive feature. The same check box is present when creating a new variable.

Retentive Variable / Memory Limitations

While retentive variables and functionality can be a useful tool when creating ladder diagram projects. There are limitations to when retentive variable usage.

As was discussed previously, retentive variables are stored in non-volatile memory (memory that retains data without power) and that retentive variable functionality is target dependent. The actual target must have non-volatile memory capability and the capability to detect a loss of power before power drops below the operating range for the target. In other words, the target must be able to sense the loss of power early enough to provide the time needed to write the retentive variables to the non-volatile memory while the target's input power is still sufficient for proper operation. This functionality is programmed at the factory level and cannot be altered in the ladder diagram project.

If designing a P13 Series PLC on a Chip™ based custom product using the PLC on a Chip™ Integrated Circuit or Module, this functionality is based on the use of the active low LOW_VOLT_SENSE pin input (Integrated Circuit Pin: 130). This pin must be connected to a circuit that can detect the loss of power early enough to allow the completion of the Retentive memory write cycle.

For Retentive memory, the P-Series PLC on a Chip™ requires an external FRAM technology device. This device connects to the PLC on a Chip using its I^{2}C ports. Please refer to the PLC on a Chip P-Series Data Sheet for details on th retentive memory requirements and the FRAM connections.

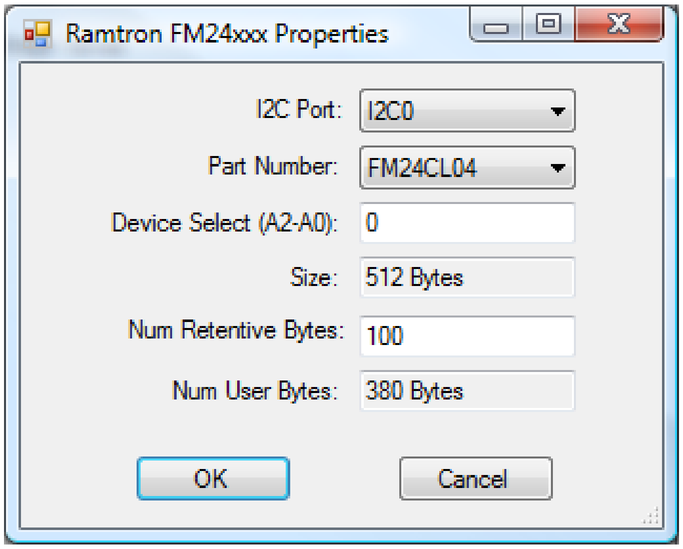
The internal EEPROM memory may not be used for retentive memory storage as the on-board EEPROM memory is too slow to allow sufficient time to complete the retentive write cycle.

The PLC on a Chip / EZ LADDER Toolkit supports multiple FRAM devices that in turn provide different size memory. Connected FRAM device memory is split into Retentive and EEPROM storage. The amount of this FRAM specified for Retentive is configured in the hardware target's Project Settings. Regardless of the memory size for Retentive, the hardware must support a loss of power detection and have sufficient power supply to allow enough time for the Retentive Memory to write successfully.

Configuring Retentive Memory in the Project Settings

To configure the Retentive Memory, use the **Project Menu** and click **Settings.** The Project Settings Window / Dialog box will open. Click the Properites button. See **Chapter 4 - Configuring Targets** for more details on target configuation menus. The *Target Properties* window will open. Located in the Devices pane, the Low Voltage Sense should be listed under Internal and under the Bus, the I^{2}C, I^{2}C port and FM24XXX should be listed. Both these items are required for retentive memory to operate correctly. If these devices are not present, they must be installed. See **Chapter 4 - Configuring Targets.**

Click on the FM24XXX (highlight) and click the **PROPERTIES** button. The RAMtron FM2xxx Properties dialog will open. This dialog is used to configure the Retentive Memory. See Figure 7-2.


Ramtron FM24xxx Properties

I2C Port: I2C0
Part Number: FM24CL04
Device Select (A2-A0): 0
Size: 512 Bytes
Num Retentive Bytes: 100
Num User Bytes: 380 Bytes

Figure 7-2

When configuring for PLC on a ChipTM, select the I2C port from the I2C Port drop-down menu and the FRAM part number from the Part Number drop-down. The Device Select should be 0 and the Size is based on the actual FRAM part number.

If the target automatically configures the FRAM device, these settings are preset.

The number of bytes on the device is divided into Number of Retentive Bytes (Num Retentive Bytes) and the Number of User Bytes (Num User Bytes). The Num Retentive Bytes are where retentive variables are stored on power loss. The Num User Bytes are used for the program to store information using the EEPROM_WRITE and EEPROM_Read function blocks.

To set the amount of retentive memory, int he Num Retentive Bytes box, enter the desired number of bytes that should be retentive, up to the maximum allowed for the device. The Num User Bytes is automatically recalculated and updated based on the value you enter for Num Retentive Bytes.

When the Retentive memory has been configured, click OK to close the Ramtron FM24xxx Properties box. Click OK to close the Target Properties window and click OK to close the Project Settings Window. Be sure to save the ladder diagram project (program) after making any changes to the Target Settings.

EEPROM Memory Overview

EEPROM memory is a non-volatile memory (meaning its values are kept in the event of a power loss) that may be used to store data from variables. The data may be stored and retrieved as needed. The EEPROM memory is ideal for storing operational parameters of a program that don't change regularly but need the ability to change.

EEPROM memory is not suited for storing values or data that changes rapidly and must be stored at each change. EEPROM technology provides a limited number of write cycles to an EEPROM location before it will fail. This number of writes before failure is large (from hundreds of thousands to millions) and does not pose any issues for items that change occassionaly; however, if a process were to try and write once per second, the number of writes would exceed the life of the EEPROM much faster. Retentive Variables and memory is better suited for rapid and repeated writes.

Installing EEPROM Fuctionality

For P-Series based PLC on a Chip targets, the EEPROM functionality may or may not be automatically installed based on the actual hardware target. If the target automatically installs the EEPROM functionality, then no other configuration is required.

If the EEPROM_READ and EEPROM_WRITE function blocks are in the function block drop down list, then the EEPROM functionality is installed and may be used.

If the EEPROM functionality is not installed and it is required for a ladder diagram project, it must be in-stalled before the EEPROM may be utilized.

To install the EEPROM device (some target knowledge is assumed, refer to the hardware target's user manual) follow these basic steps. A VB-2000 is used as the example hardware target. All others will install similarly.

1. In EZ LADDER, from the File Menu at the top, click **PROJECT** then **SETTINGS**. This will open the Project Settings Window. Select **VB-2000** as the target from the choices.

2. Click the **PROPERTIES** button to the right side of the window. The VB-2000 Properties Window will open. Make sure the proper model (Part Number) is selected in the drop-down menu. Refer to Figure 7-3

3. Click the **ADD DEVICE** button. The *PLCHIP-PXX Devices* window will open. Locate the PLCHIP_Pxx_eeprom in the Devices pane of this window. Refer to Figure 7-4.

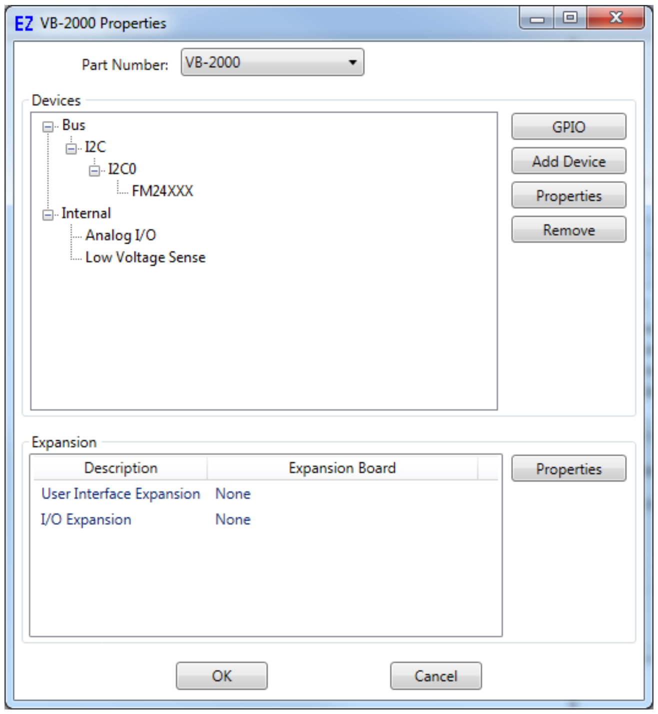
4. Click the ***PLCHIP_Pxx_eeprom*** device (highlight) and click **OK**.

5. The PLCHIP_Pxx_eeprom is now listed as an internal device in the Devices Pane. Click **OK** to close the *VB-2XXX Properties*.

9. Click **OK** to close the *Project Settings* Window.

10. Save your ladder diagram using the menu **FILE** and **SAVE** or **SAVE AS** to save the current settings in your program.

The EEPROM functionality is now installed in the ladder diagram program. The EEPROM_WRITE and EE-PROM_READ function blocks should now be available in the function block drop down list.



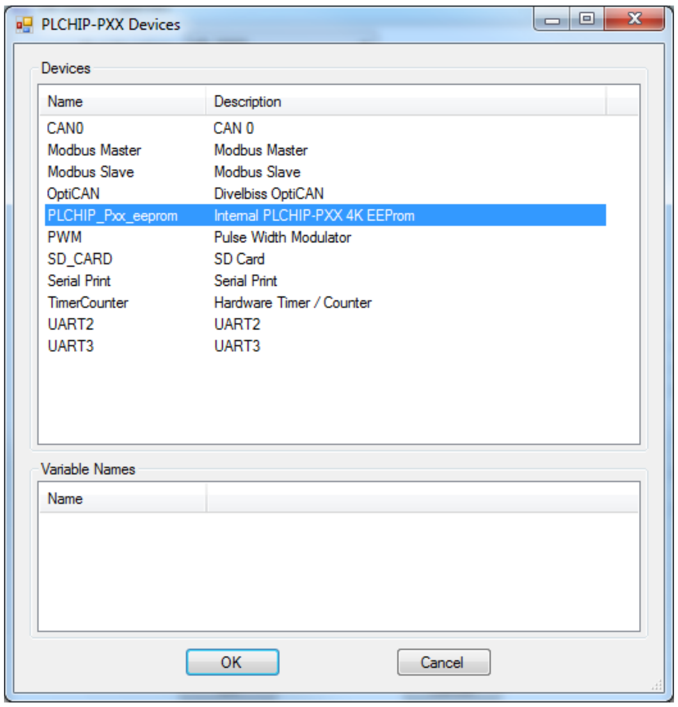
Part Number: VB-2000

Devices
- Bus
  - I2C
    - I2C0
      - FM24XXX
- Internal
  - Analog I/O
  - Low Voltage Sense

Expansion

Description	Expansion Board
User Interface Expansion	None
I/O Expansion	None

Figure 7-3



Devices

Name	Description
CAN0	CAN 0
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
TimerCounter	Hardware Timer / Counter
UART2	UART2
UART3	UART3

Variable Names

Name	

Figure 7-4

Using EEPROM Memory

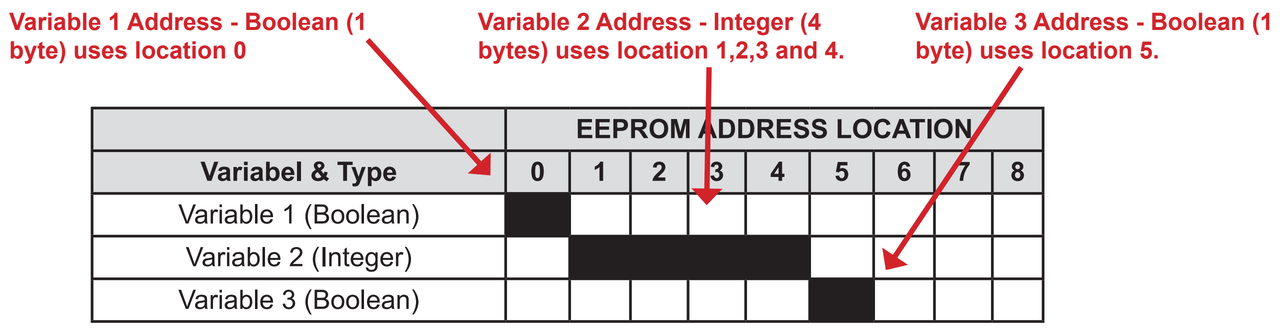
EEPROM memory is accessed by using the EEPROM_WRITE and EEPROM_READ function blocks. The EEPROM_WRITE and EEPROM_READ function blocks use variables to set the EEPROM address.

To write and read values from the EEPROM, you must understand that the EEPROM memory is basically a bank of memory and the variable values may be stored into this bank. The EEPROM bank is organized by per byte and each variable type has a specific number of bytes that it will require. Boolean variables fill two bytes while all other variable types fill four bytes of EEPROM.

The address provides the location where to store the variable or from where to read the data into a variable from. The actual address is the first byte location of the EEPROM memory. Each EEPROM address is absolute and is one byte in size. To correctly store and read variables (of the same or different type), they must be mapped based on the starting byte location (address) and the number of bytes to store or read for the variable type.

When writing a boolean to address 0, the actual variable will use addresses 0 (one byte). Should you write an integer variable into address 0, then it would use addresses 0-3 (4 bytes). A memory map should be created and used to assign variable types and addresses prior to coding to ensure that variable size and types are accounted for.

You must use the same address for writing and reading a variable for correct operation. If the addresses are not the same and/or you have overwritten some bytes of where a value is stored, the data read will be corrupted.


Variable 1 Address - Boolean (1 byte) uses location 0

Variable 2 Address - Integer (4 bytes) uses location 1,2,3 and 4.

Variable 3 Address - Boolean (1 byte) uses location 5.

	EEPROM ADDRESS LOCATION								
Variabel & Type	0	1	2	3	4	5	6	7	8
Variable 1 (Boolean)	■								
Variable 2 (Integer)		■	■	■	■				
Variable 3 (Boolean)						■			

Refer to **Chapter 24 - Function Reference** for details on using the EEPROM_READ and EEPROM_WRITE function blocks.

FRAM used as EEPROM

When configuring Retentive Memory (see earlier this Chapter), the NumUser Bytes are automatically calculated based on the number of retentive bytes configured. The NumUser Bytes are memory locations in FRAM that may be used to store data just as in the EEPROM using the EEPROM_WRITE and EEPROM_READ function blocks.

The FRAM memory locations as they are not based on EEPROM technology do not have the write cycle limitations. FRAM locations will not fail after repeated write cycles; therefore, they are appropriate to use in any situation.

When using the EEPROM_READ or EEPROM_WRITE function block, ensure you select the correct device from the drop down menu (the menu is available when placing the function blocks in the ladder diagram). The FMXXX devices are FRAM devices while the PLCHIP_Pxx_eeprom is the actual PLC on a Chip EEPROM.

CHAPTER 8

Pulse Width Modulation

This chapter provides basic information to understand what Pulse Width Modulation is and how it is used as feature in the EZ LADDER Toolkit and hardware target.

Chapter Contents

What is Pulse Width Modulation

Pulse Width Modulation, also referred to as PWM is a term common to the industrial controls and electronics industries. Essentially PWM is generally an output that can be controlled in such a manner that will cause a device connected to have varying operation. Consider a light dimmer, changing the knob changes the light intensity; this is how a PWM output can affect a load such as a light.

PWM does what it's name implies. By turning a PWM output on at a fast rate, the load device will appear to be on all the time even though it is actually being turned on and off quickly. The rate at which the PWM output is turned on and off is called the *frequency*. As the frequency changes (faster or slower), the result on the load device changes like the light example from bright to dim. The PWM outputs a square-wave and the time on vs the time off is the *duty cycle*. Figure 8-1 illustrates an example PWM output waveform.

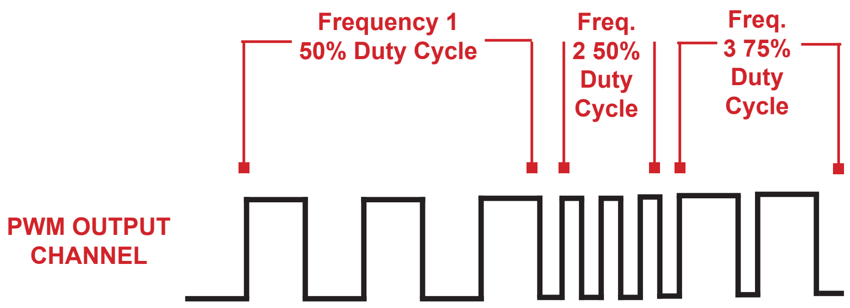


Figure 8-1

PWM Output Basics

Pulse Width Modulation (PWM) Outputs for P-Series targets are easy implement and utilize using the EZ LADDER Toolkit. PWM channels are 32 bit resolution and up to 12 channels are available based on the actual hardware target.

PWM functionality, supported types and number of channels is always target dependent. While EZ LADDER Toolkit provides the basic programmability, the hardware target must support PWM and the selected configuration for the PWM outputs to operate correctly.

PWM output frequency is dependent upon the actual hardware target and the resolution configured. Changing the resolution (or hardware target) may change the acceptable range of the PWM outputs.

Configuring PWM in Project Settings

As with most EZ LADDER Toolkit hardware supported features, the PWM channels and functionality must installed and configured before it may be used in a ladder diagram project. The PWM channels are configured using the Project Settings. Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the PROPERTIES button. The Target Properties window will open. If PWM is already listed in the *Devices pane*, you can select it (highlight) and click the PROPERTIES button to make additional configurations to the PWM. If the PWM is not listed in the *Devices pane*, it must be installed and configured. Figure 8-2 shows no installed devices.

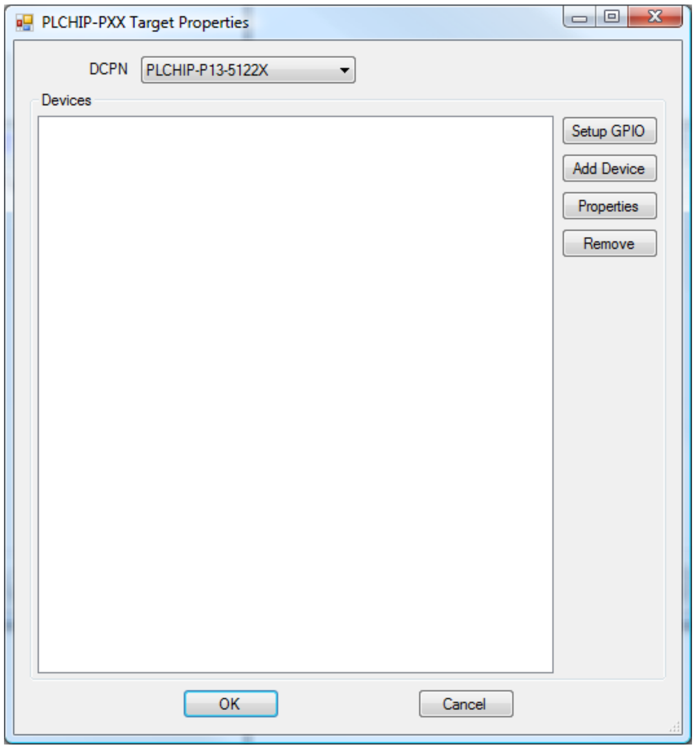
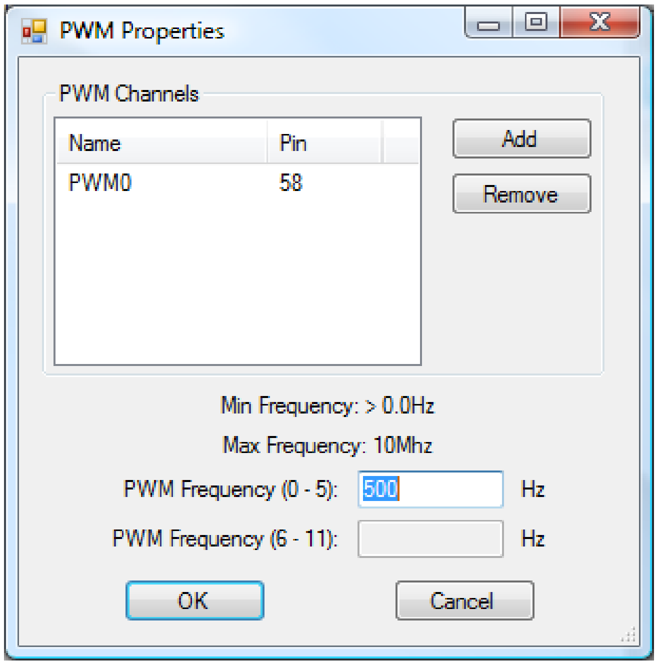


Figure 8-2

To install the PWM, click the ADD DEVICE button. The *Devices window* will open. Choose **PWM** from the devices (click to highlight) and then click OK. The *PWM Properties* window will open. See Figure 8-3.

Click the ADD button, the *Add PWM Channels* dialog will open. Select the channel(s) and click OK to add them.

There are up to 12 channels available based on the target. Channels 0-5 operate on a base PWM frequency and channels 6-11 operate on a different base PWM frequency. These frequencies are > 0 Hz and up to 10 MHz. Enter the base frequency desired for the channels that have been added. Click OK to close the PWM Properties window, click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project (program).



PWM Properties

PWM Channels

Name	Pin
PWM0	58

Min Frequency: > 0.0Hz

Max Frequency: 10Mhz

PWM Frequency (0 - 5): 500 Hz

PWM Frequency (6 - 11): Hz

Figure 8-3

The actual PWM base frequency will be application dependent. The PWM frequency can be changed in the ladder diagram program using the PWM_FREQ function block.

Controlling PWM in the Ladder Diagram Project

With PWM channels configured in the Project Settings, it is simple to control the actual PWM channels in the ladder diagram project.

Enabling a PWM Channel

To control a PWM output, specifically when it is enabled, disabled and it's duty cycle, the ***PWM*** function block is used. This function block has two inputs (EN for Enable and DC for Duty Cycle) and also has one output (Q). When the PWM function block is enabled (the EN input is true), the PWM channel is active and operating at the frequency defined in the project settings and the Duty Cycle (variable connected to DC of the PWM function block). When the EN input is false, the PWM channel output is disabled. Figure 8-4 illustrates the PWM function block in a sample circuit.

When placing the PWM function block, a new dialog is opened to select the PWM channel and the polarity of the PWM Channel.

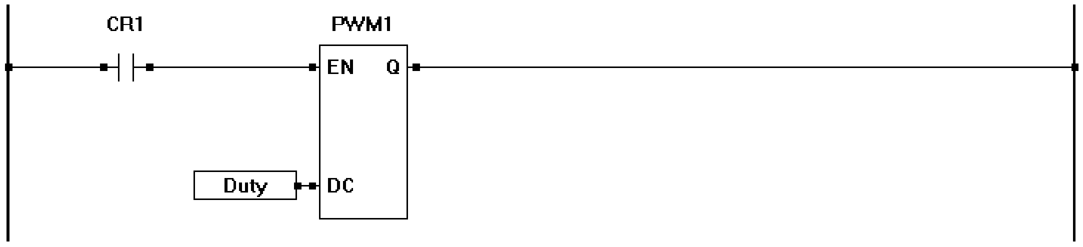


Figure 8-4

Controlling the PWM Channel Duty Cycle

The PWM output's duty cycle is controlled the PWM function block for that channel. Changing the value of the variable connected to the DC input of the PWM function block immediately changes the duty cycle accordingly. This gives a PWM output the ability to change duty cycle in real-time in response to control parameter changes.

Changing the PWM Frequency

In addition to an adjustable duty cycle, the PWM clock frequencies (CLK A / CLK B) can be changed in the ladder diagram project by use of the PWM_FREQ function block. The PWM_FREQ function block has two inputs (EN for enable and F for frequency) and one output (Q). When the EN is true, the PWM channel frequency is changed to the value of the variable connected to the F input of the function block. Figure 8-4 illustrates a sample circuit using PWM_FREQ.

When using the PWM_FREQ to change the frequency, the actual CLK A or CLK B frequency is changed. This affects all channels that use that specific CLK signal. For example, if PWM channel 0 uses CLK A and PWM channel 2 uses CLK A, then adjusting the frequency using PWM_FREQ to CLK A affects all the PWM channels that use CLK A, in this case 0 and 2 respectively.

When placing the PWM_FREQ function block, a new dialog is opened to select the PWM channel Clock.

The PWM clock frequency will be equal to the value of the F input of the PWM_FREQ function block, thus allowing real-time frequency changes.

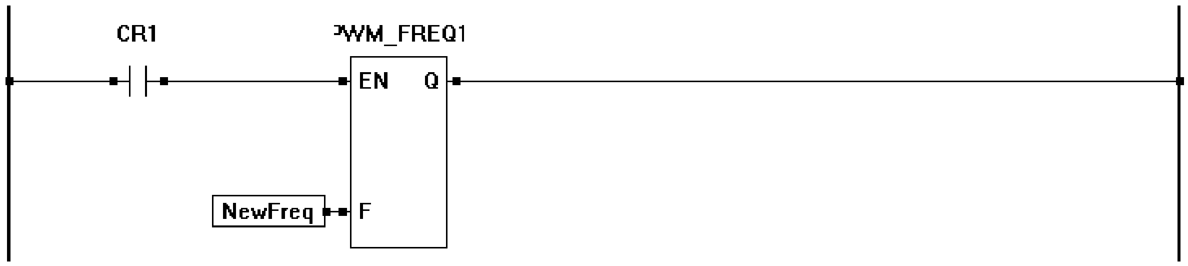


Figure 8-5

CHAPTER 9

LCD Display Support

This chapter provides basic information to understand how to install, configure and use an LCD Display with the EZ LADDER Toolkit

Chapter Contents

LCD Display Functionality

EZ LADDER Toolkit provides the ability to display text and variables using it's built-in LCD support. EZ LADDER Toolkit supports LCD displays that meet the HD44780 interface specification. In addition to the specification, the displays must have 1 to 4 rows and 8-40 columns>

LCD support is based on actual hardware target specifications. PLC on a Chip™ Integrated Circuits and Modules support LCD display functionality. For PLCs and controllers, refer to the supported features. See **Chapter 23 - Hardware Targets**.

EZ LADDER Toolkit supports only one LCD display in a ladder diagram project.

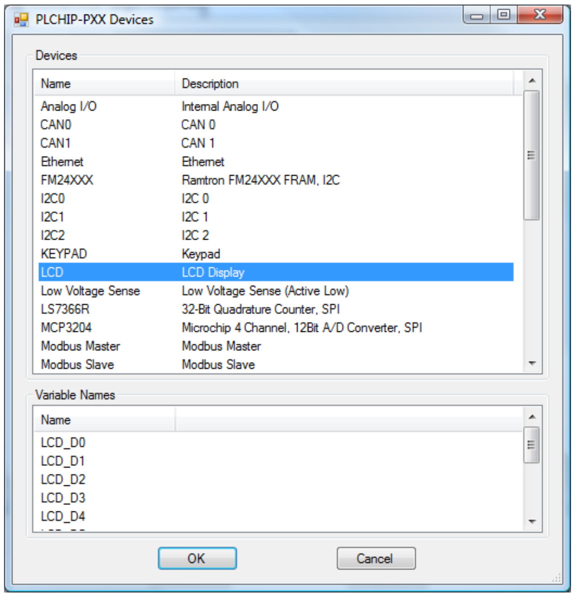
Configuring the LCD Display in the Project Settings

To be able to use an LCD display in an EZ LADDER Toolkit ladder diagram project, the LCD display must first be installed and configured. The LCD display is configured using the Project Settings.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN) , select the actual part number (if not already done). In the Device section of the Devices Pane, if the LCD is installed, it will be displayed. To install the device, click the **ADD DEVICE** button. The *Target Devices* window will open.

All the available devices and features for the target are shown in the Devices section. Scroll down and find LCD. Figure 9-1 shows the Target Devices window.

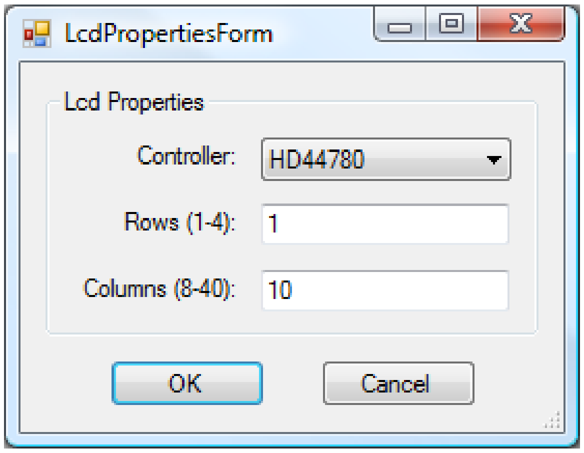


Name	Description
Analog I/O	Internal Analog I/O
CAN0	CAN 0
CAN1	CAN 1
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C1	I2C 1
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave

Name
LCD_D0
LCD_D1
LCD_D2
LCD_D3
LCD_D4

Figure 9-1

Click **LCD** and click OK. The LCDpropertiesForm dialog will open. using this dialog set the number of Rows (1-4) and the number of Columns (8-40). Click OK when the LDC properties are entered to close the dialog and return to the Target Properties Window. You will now see the LCD listed in the Devices pane. See Figure 9-2 for setting the rows and columns.


LcdPropertiesForm

Lcd Properties

Controller: HD44780

Rows (1-4): 1

Columns (8-40): 10

Figure 9-2

Click the OK button to close the *Target Properties* window and click OK to close the *Project Settings* window. Be sure to save the ladder diagram project (program).

The LCD display can now be utilized from the ladder diagram project.

Displaying Messages on the LCD Display

With the LCD display configured in the ladder diagram project, it is now possible to use the EZ LADDER Toolkit's function blocks to display messages and variables. Two basic function blocks that are used control the display are: LCD_CLEAR and LCD_PRINT.

Clearing the Display

To clear the LCD display (blank all rows and columns), the LCD_CLEAR function block is used. The LCD_ CLEAR will clear the display when it senses a rising edge on it's enable input (EN). Figure 9-3 shows an example program using the LCD_CLEAR function block.

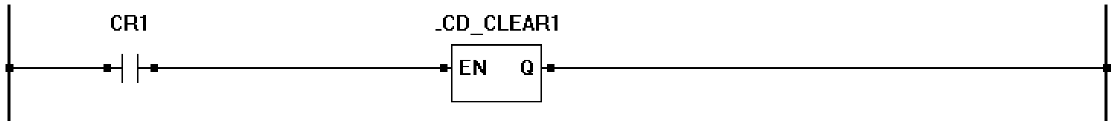
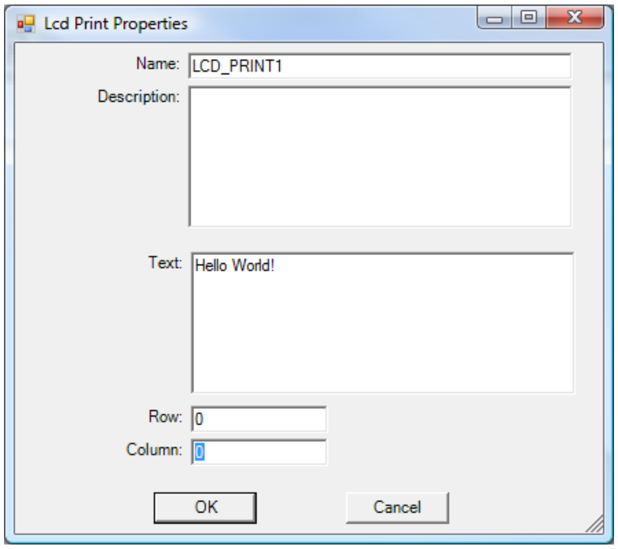


Figure 9-3

Writing to the Display

To write messages to the LCD Display, the LCD_PRINT function block is used. Using the LCD_PRINT function block is a two step process. When placing the function block, a new Lcd Print Properties dialog box will open. See Figure 9-4. The *Text* field is where the message is typed that will be displayed. The *Row* field is the row of the display where the text will be displayed. The Column field is the column where the text will begin displaying.


Lcd Print Properties

Name: LCD_PRINT1

Description:

Text: Hello World!

Row: 0

Column: 0

Figure 9-4

The first row and first column are always zero (0) and are limited by the actual hardware target display size. If text in a row is more than can be displayed on the LCD, it will be truncated. It does not automatically wrap to the next line. Each row of the display must be written to individually with separate LCD_PRINT function blocks.

When all the information is entered, clicking OK will cause the function block to be placed in the ladder diagram project. Figure 9-5 is a sample of a complete LCD_PRINT circuit.

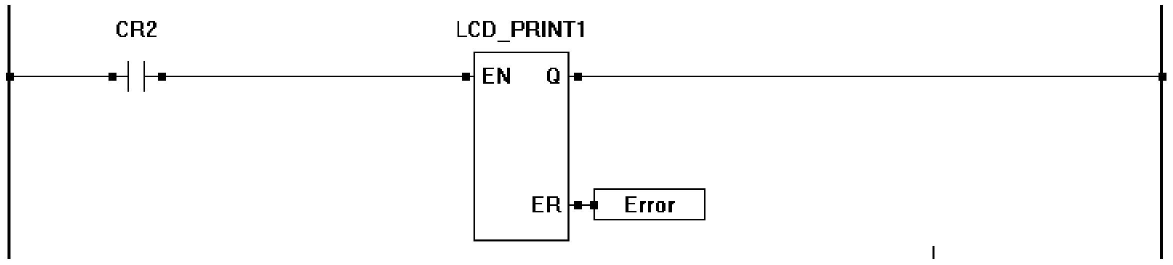
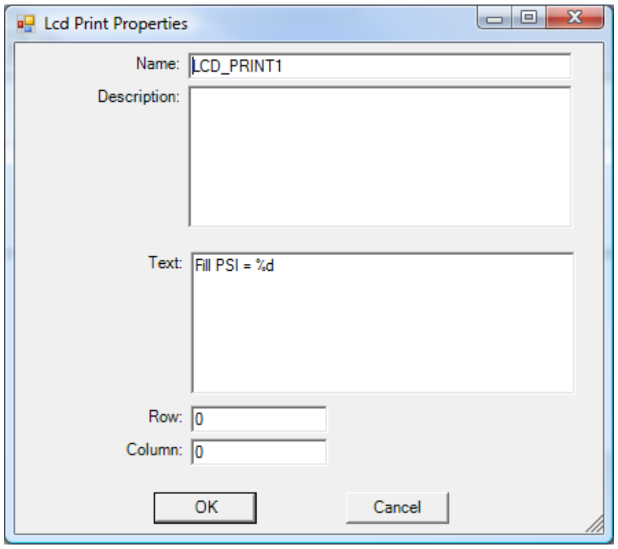


Figure 9-5

Writing Variables to the Display

In addition to printing static text, it is often desirable to be able to print variables to the display. This is helpfulin displaying process parameters and menu items. To write a variable to the LCD display, the same LCD_PRINT function block is still used. As in the simple text printing, the text is entered into the *Text* field.

In addition to the text, *control characters* may be inserted that represent variables and how to format the variable text. For a full listing of what control characters and formatting is supported, please see the LCD_ PRINT function block in **Chapter 24 - Function Reference.** Figure 9-6 illustrates a sample text dialog with control characters.



Name: LCD_PRINT1
Description:
Text: Fill PSI = %d
Row: 0
Column: 0

Figure 9-6

When an LCD_PRINT function is inserted to display variables, a new variable input is added to the function block automatically for each variable that will be displayed.

Figure 9-7 represents a sample ladder diagram project using a LCD_PRINT function block with a variable input that will be displayed.

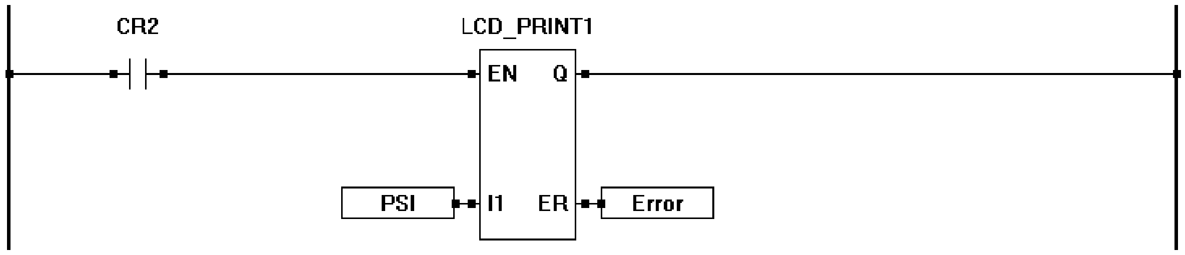


Figure 9-7

The LCD_PRINT function block is rising edge sensitive. Therefore, it will only display one time as the ENable input goes high. The text will appear normally, but the variable will not appear to update or change as the ladder diagram is executing.

To overcome the rising edge issue when displaying variable, create TON timer circuit as shown in Figure 9-8 and use the timer contact to act as a refresh for the ENable input on the LCD_PRINT function block. The refresh timer should be adjusted to your display preferences. in Figure 9-8, CR1 will toggle on and off based on the Timer function TON, giving the result of the LCD_PRINT seeing a rising edge at that timing rate.

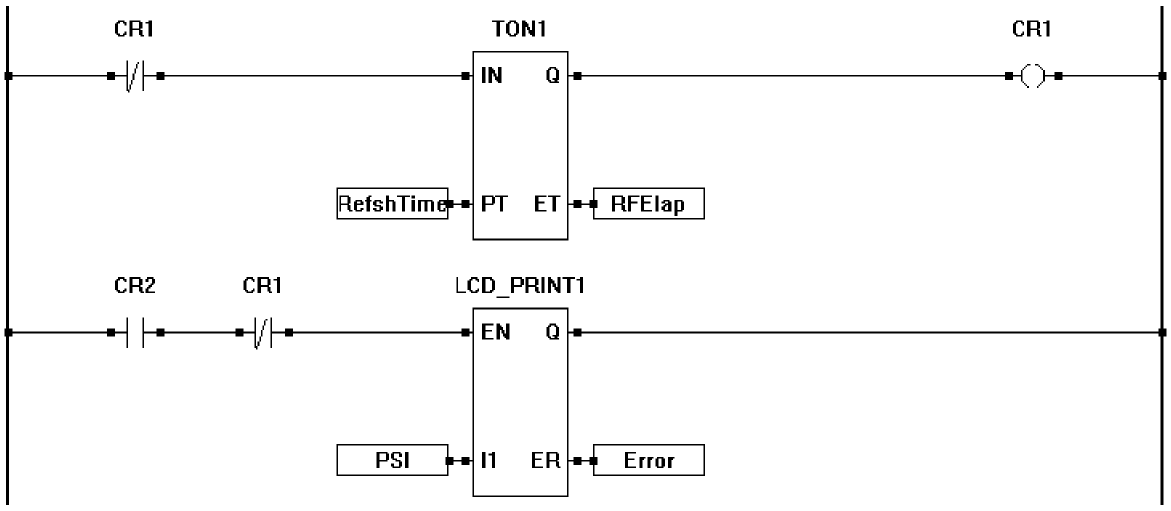


Figure 9-8

For more detail on all EZ LADDER Toolkit Function Blocks and objects, refer to **Chapter 24 - Function Reference**.

CHAPTER 10

Keypad Support

This chapter provides basic information to understand how to install, configure and use the Keypad feature in the EZ LADDER Toolkit.

Chapter Contents

Keypad Functionality

EZ LADDER Toolkit provides the ability for the addition of keypad functionality. EZ LADDER Toolkit supports a basic 4 row, 5 column keypad matrix. This keypad matrix includes the numbers 0-9, Enter, Clear, Up, Down, +/-, Decimal Point, and F1-F4 (programmable function keys). Using this keypad matrix and the built-in EZ LADDER functions, menus and user interactions may be programmed into a ladder diagram project.

Keypad support is based on actual hardware target specifications. PLC on a Chip^{TM} Integrated Circuits and Modules support Keypad functionality. For PLCs and controllers, refer to the supported features. See **Chapter 23 - Hardware Targets**.

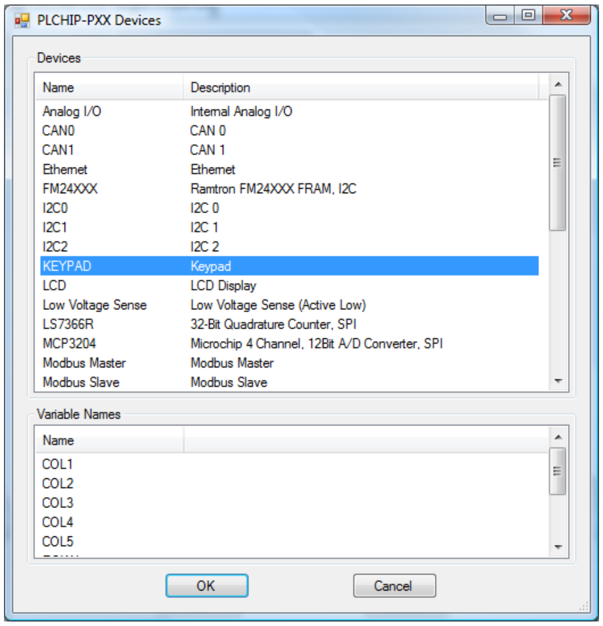
Configuring the Keypad in the Project Settings

To be able to use an keypad in an EZ LADDER Toolkit ladder diagram project, the keypad must first be installed and configured. The keypad is configured using the Project Settings.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If the keypad were installed, it would be listed in the *Devices pane* under the Devices section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open.

All the available devices and features for the target are shown in the Devices section. Scroll down and find Keypad. Figure 10-1 shows the Target's Devices window.



Name	Description
Analog I/O	Internal Analog I/O
CAN0	CAN 0
CAN1	CAN 1
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C1	I2C 1
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave

Name
COL1
COL2
COL3
COL4
COL5

Figure 10-1

Click *Keypad* and click OK. The Devices window will close and return to the Target Properties window. The Device section will now list the Keypad as an installed device. Refer to Figure 10-2.

No additional configuration is required to begin using the Keypad. Click OK close the Target Properties window and click OK again to close the Project Settings window. Use the File Menu and Save the ladder diagram project. The keypad matrix can now be utilized from the ladder diagram project

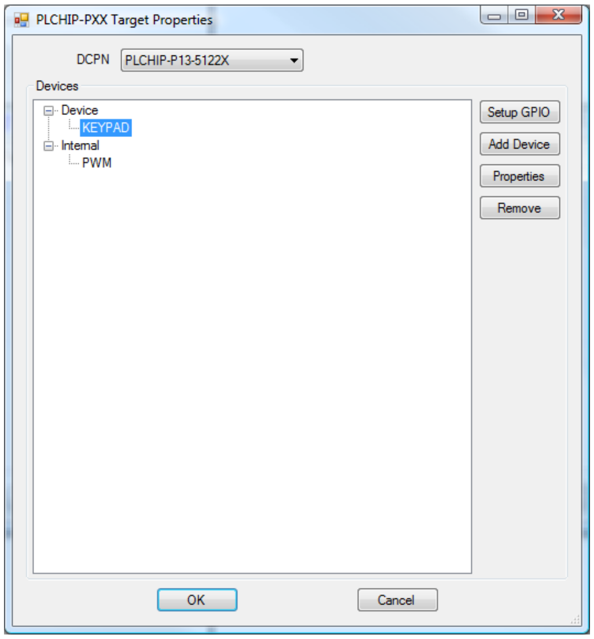


Figure 10-2

Getting Data from the Keypad

With the keypad configured in the ladder diagram project, it is now possible to use the EZ LADDER Toolkit's function blocks and objects to input user data and set points. The keypad can be read using two methods. The two methods are: Integer and Real Variable entry using the Keypad Function block and the second is identifying discrete key presses using contacts.

Real and Integer Inputs using the Keypad Function Block(s)

There are two Keypad function blocks provided for use in the ladder diagram program, Keypad and Keypad2.

Using the KEYPAD Function

To read data (integer or real) from the keypad using the KEYPAD function block, select the KEYPAD function block from the drop-down menu and place it in the ladder diagram at the desired location. The Keypad block will be inserted into the ladder diagram.

Each keypad function block has three inputs and three outputs. As with all function blocks, the EN (enable) will enable the keypad function block or disable it. The MI and MA inputs are used to identify Minimum and Maximum allowed entries respectively. The Q Output is true when the function is enabled. The KB output will maintain the contents of the keypad buffer while KO is the actual value that was entered on the keypad (and **ENTER** pressed). Figure 10-3 represents a typical keypad function in a ladder diagram project.

The Keypad function block can be used to input real or integer variables. When connecting a variable, the type connected will limit all number inputs and outputs to the selected type (all integer or all real).

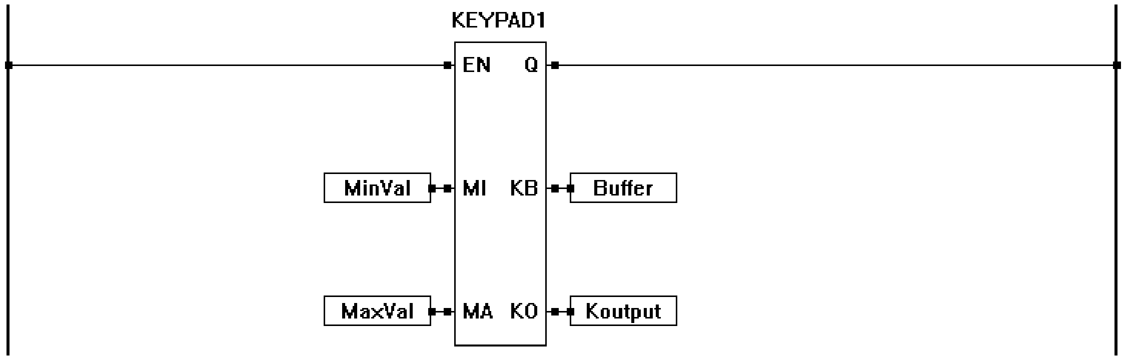


Figure 10-3

Using the KEYPAD2 Function

The Keypad2 function block provides additional features over the Keypad function block. These featues allow menus and Discrete key press menu items to be combined, allowing for a more powerful and easier to implement menu.

To read data (integer or real) from the keypad using the KEYPAD2 function block, select the KEYPAD2 function block from the drop-down menu and place it in the ladder diagram at the desired location. The Keypad2 block will be inserted into the ladder diagram.

Each keypad2 function block has three inputs and six outputs. As with all function blocks, the EN (enable) will enable the keypad2 function block or disable it. The MI and MA inputs are used to identify Minimum and Maximum allowed entries respectively.

The Q Output is true when the function is enabled. The KB output will maintain the contents of the keypad buffer while KO is the actual value that was entered on the keypad (and **ENTER** pressed). The M output is a boolean that is set to true when any number (0-9), + or . is pressed. Pressing the Clear or Enter will reset the M output to false. The KP output is a boolean output that is true only for the single scan that a key was pressed. The KY output is an integer output of the actual ASCII value of the key that was pressed.

Figure 10-4 shows the ASCII output for the key press detected.

Figure 10-5 represents a typical keypad2 function in a ladder diagram project.

KEY	ASCII Value	KEY	ASCII Value
0	48	F1	65
1	49	F2	66
2	50	F3	67
3	51	F4	68
4	52	UP	69
5	53	DOWN	70
6	54	ENTER	13
7	55	CLEAR	8
8	56	Decimal Point (.)	46
9	57	+ / -	45

Figure 10-4

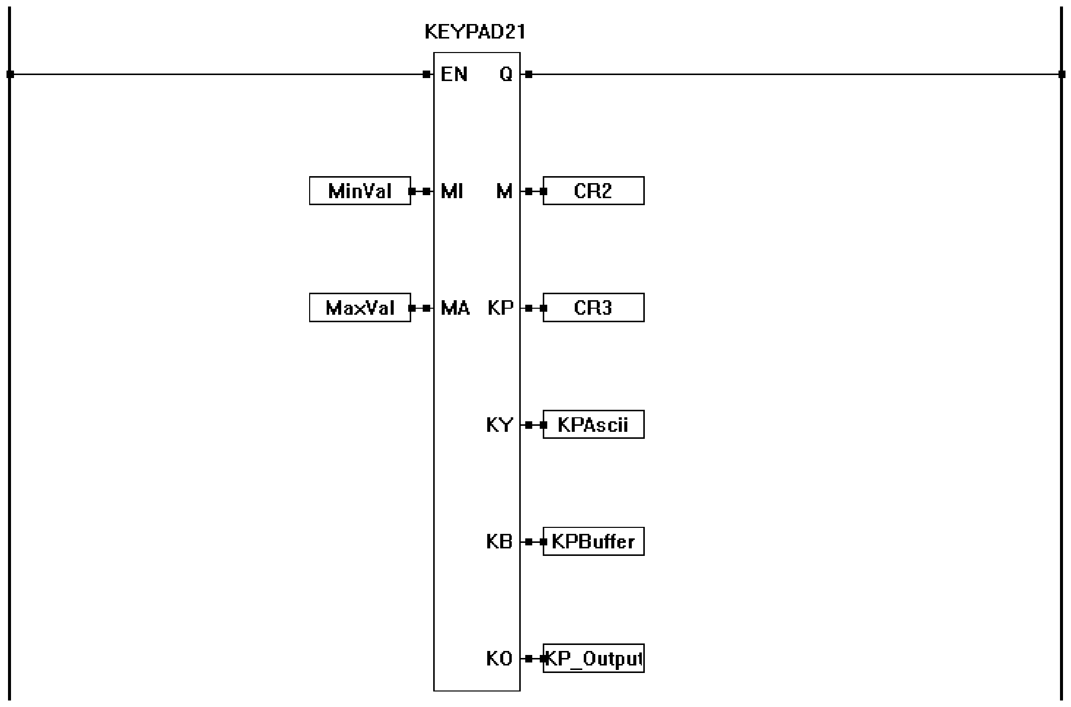


Figure 10-5

Reading Discrete Key Presses using Contacts

Before being able to read any key presses using the Discrete key method, the ladder diagram must have at least one Keypad (or Keypad2) Function Block installed and in use. Any discrete keys will not operate unless one Keypad (or Keypad2) Function Block is installed in the ladder diagram project.

In addition to reading complete values from the keypad, it is possible to read individual keys to determine if they are pressed. Each key has a predefined address that can be used as an input (boolean type variable that is classified as an input). Create a contact as a new variable, and in the ***Var I/O Number*** field, enter the address of the specific key desired. When the key is pressed, the contact will be true.

The following addresses are used to read discrete keypad buttons.

I/O Assignment	Button Description	I/O Assignment	Button Description
KB_0	Numeric 0	KB_CLEAR	Clear Button
KB_1	Numeric 1	KB_DP	Decimal Point Button
KB_2	Numeric 2	KB_+-	+ / - Button
KB_3	Numeric 3	KB_F1	F1 Button
KB_4	Numeric 4	KB_F2	F2 Button
KB_5	Numeric 5	KB_F3	F3 Button
KB_6	Numeric 6	KB_F4	F4 Button
KB_7	Numeric 7	KB_UP	Up Button
KB_8	Numeric 8	KB_DOWN	Down Button
KB_9	Numeric 9	KB_ENTER	Enter Button

For more detail on all EZ LADDER Toolkit Function Blocks and objects, refer to **Chapter 24 - Function Reference**.

CHAPTER 11

UARTS and Serial Ports

This chapter provides basic information to understand how to install, configure and use the UARTS, Serial Ports and to enable the Serial Printing feature in the EZ LADDER Toolkit.

Chapter Contents

UARTS & Serial Ports

EZ LADDER Toolkit provides provides the software interface to bring P-Series hardware target's commun-ciation ports to life. These serial ports (name UARTS in EZ LADDER) may be used to communicate Modbus Master or Slave, Print Serially to external devices and even transmit or receive data using Structured Text. For more information about structured text, see **Chapter 26 - Structured Text**.

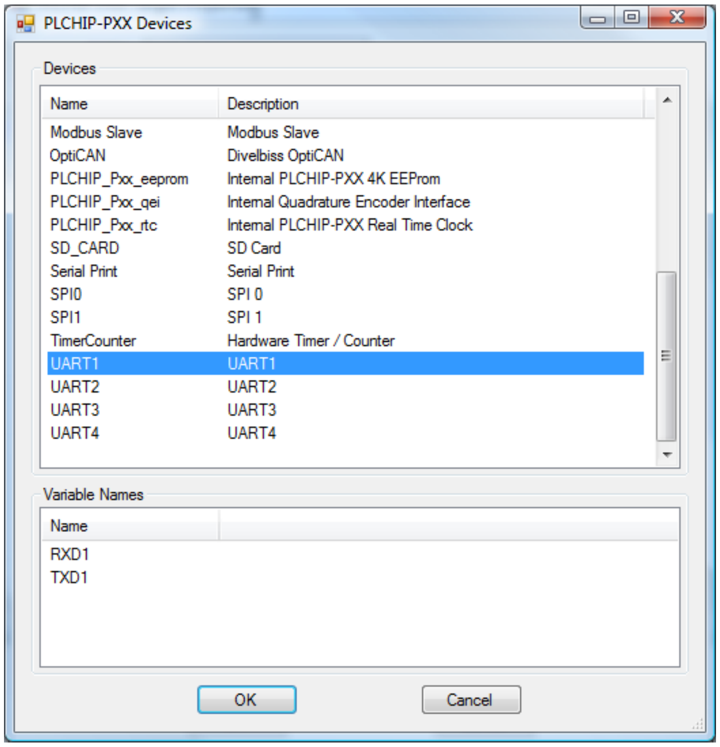
The availbility of UARTs (Serial Ports) is entirely dependent upon the actual target. For more information regarding hardware target support and features, see **Chapter 23 - Hardware Targets.**

Prior to using the UARTs in EZ LADDER Toolkit, the UART(s) must be installed and configured in the target. The UARTs are configured using the Project Settings.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If any UARTs were installed, they would be listed in the *Devices pane* under the Bus/Uart section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open.

All the available devices and features for the target are shown in the Devices section. Scroll down and find the UARTS (UART1 - UART4). Figure 11-1 shows the Target's Devices window.



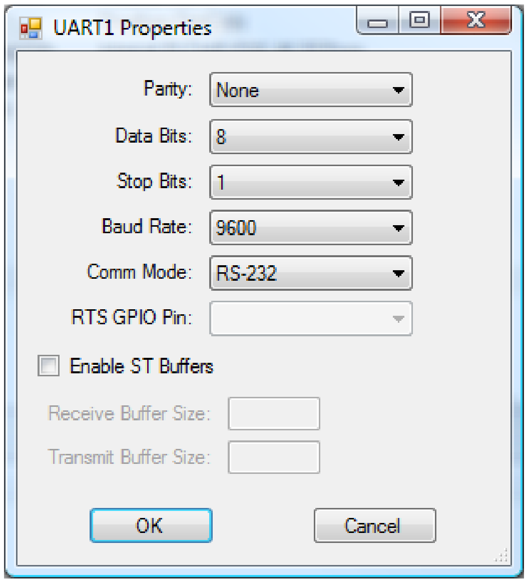
Name	Description
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0
SPI1	SPI 1
TimerCounter	Hardware Timer / Counter
UART1	UART1
UART2	UART2
UART3	UART3
UART4	UART4

Variable Names

Name
RXD1
TXD1

Figure 11-1

Select the UART required and click OK. The UARTx Properties dialog box will open. The parameters for the UART are set in this dialog. See Figure 11-2.


UART1 Properties

Parity: None

Data Bits: 8

Stop Bits: 1

Baud Rate: 9600

Comm Mode: RS-232

RTS GPIO Pin:

[ ] Enable ST Buffers

Receive Buffer Size:

Transmit Buffer Size:

Figure 11-2

Configure the UART by setting each of the parameters to your hardware and applications needs.

Parity:	Parity. Select from None, Even and Odd.
Data Bits:	Number of Data Bits. Select from 5, 6, 7 or 8.
Stop Bits:	Number of Stop Bits. Select from 1 or 2.
Baud Rate:	Baud Rate. Select from 9600, 19200, 28400, 57600 and 115200
Comm Mode:	Communications Mode. Select from RS232, RS422 or RS485. Select the type of communication interface. Communications Mode is subject to the actual hardware features available.
RTS GPIO Pin:	Request to Send GPIO. For RS485, a GPIO (output) is required to hand the transmit / receive pin on the RS485 transceiver. The connected GPIO to the transceiver should be specified here.
Enable ST Buffers:	Check box to enable the Transmit / Receive buffers for use with Structured Text.
Receive Buffer Size:	Receive Buffer Size for Structured Text. Enter the number of bytes to buffer.
Transmit Buffer Size:	Transmit Buffer Size for Structured Text. Enter the number of bytes to buffer.

When configured, click OK to close the UARTx Properties dialog and return to the Target Properties window.

Click OK to close the Target Properties window and click OK to close the Project Settings window.

The UART is now installed. The UART supports the use of Modbus Master, Modbus Slave, Serial Printing and Structured Text.

The UART baud rate may be changed in the ladder diagram program by using the UART_SET_PROPERTY function block.

For Modbus Master / Slave, see **Chapter 13 - Modbus Networking**.
For Structured Text, see **Chapter 26 - Structured Text**.

Serial Print Functionality

EZ LADDER Toolkit provides the ability to serially print text and variables to other devices using a serial port. This feature can be useful to send data to data loggers, displays and other devices. The serial print feature utilizes a standard serial port (UART) that may be configured as RS232, RS422 or RS485 and can operate with multiple baud rates.

Serial Printing support is based on actual hardware target specifications. PLC on a Chip™ Integrated Circuits and Modules support Serial Printing functionality as well as do some standard Divelbiss PLCs and Controllers.. For PLCs and controllers, refer to the supported features. See **Chapter 23 - Hardware Targets**.

Installing / Configuring the Serial Print Device

As with most features, the Serial Print feature must be installed and configured in the EZ LADDER Toolkit before it may be used.

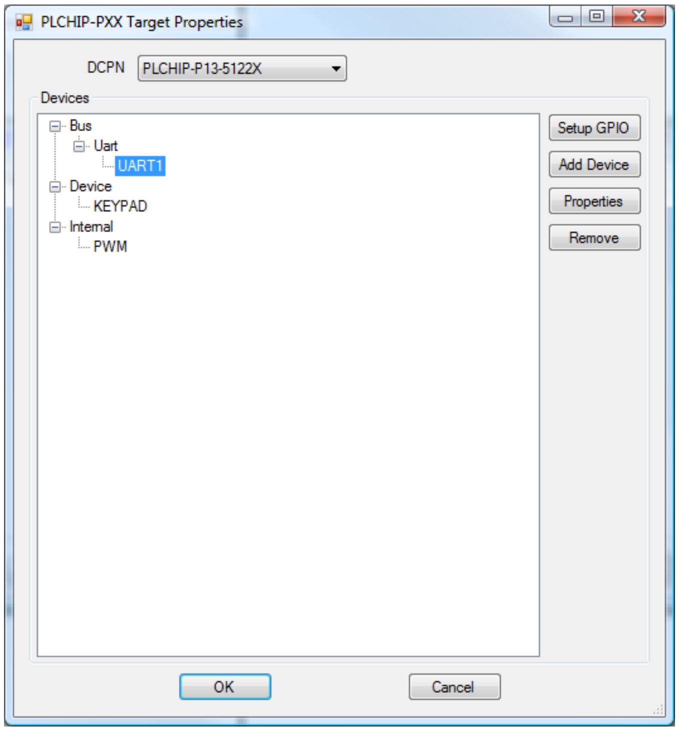
The Serial Print is configured using the *Project Settings*. Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the PROPERTIES button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the part number / model number if not selected.

Verify the UART to be used for serial printing is installed. The UART to be used must be installed prior to installing the Serial Printing device / feature. See Figure 11-3. If not installed, please see the UARTS & Serial Ports section of this Chapter.

Click the ADD DEVICE button. The ***Targets Devices*** window will open.

All the available devices and features for the target are shown in the Devices section. Scroll down and find Serial Print. Figure 11-4 shows the Device Properties window.

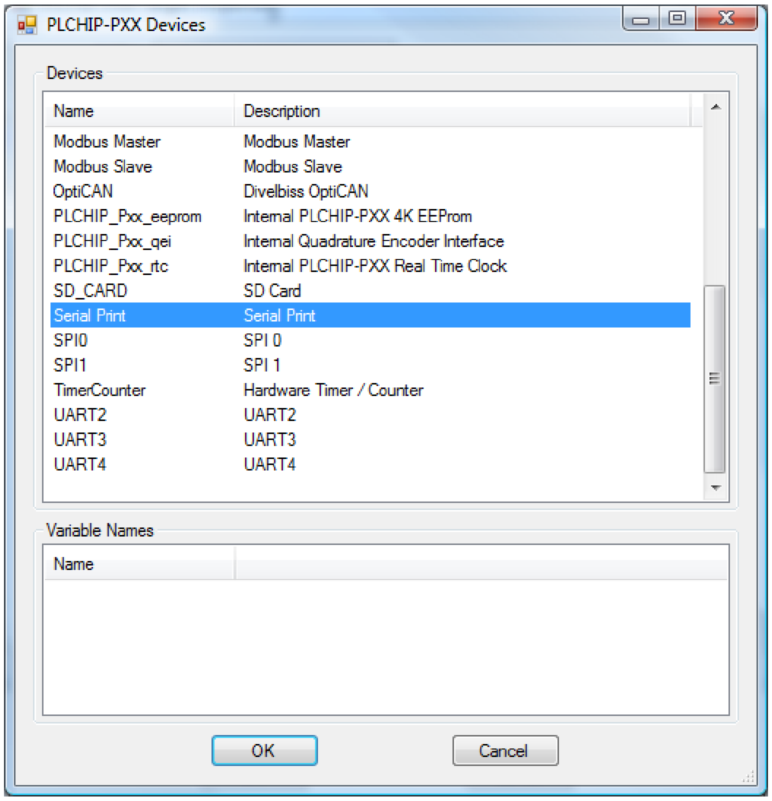

PLCHIP-PXX Target Properties

DCPN PLCHIP-P13-5122X

Devices

- Bus
  - Uart
    - UART1
- Device
  - KEYPAD
- Internal
  - PWM

Figure 11-3


PLCHIP-PXX Devices

Devices

Name	Description
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0
SPI1	SPI 1
TimerCounter	Hardware Timer / Counter
UART2	UART2
UART3	UART3
UART4	UART4

Variable Names

Name	

Figure 11-4

Click *Serial Print* and click **OK**. The Serial Print Properties window will open. This window is used to configure the Serial Print properties. See Figure 11-5.

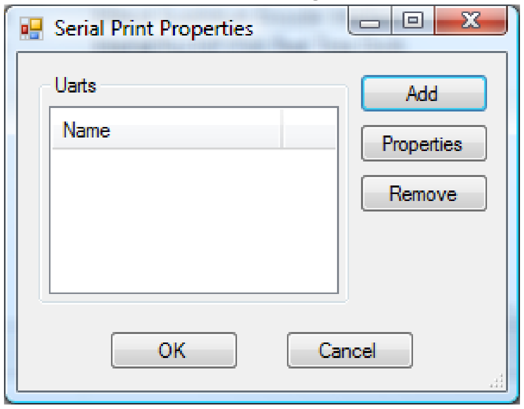
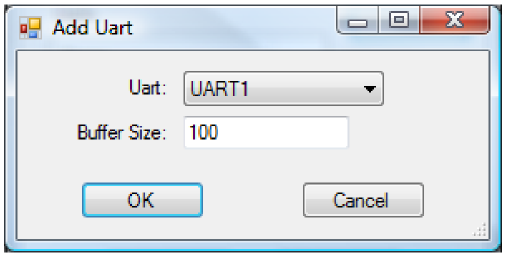


Figure 11-5

Click the **ADD** button. The Add Uart dialog will open. Select the UART to use from the drop-down Uart menu and enter the number of bytes to use for the buffer size for the UART. See Figure 11-6.



Uart: UART1
Buffer Size: 100

Figure 11-6

Click **OK** to close and save the Add Uart Dialog. The Uart is now listed in the Uarts Box of the Serial Print Properties window. Click **OK** to close the Serial Print Properties Window.

The targets Devices window will close and the previous target properties window will now list the Serial Print as an installed device under the Device section.

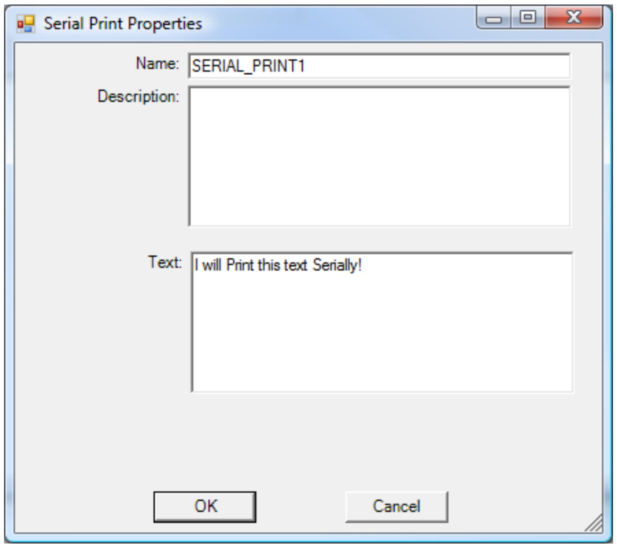
Click **OK** close the Target's properties and click **OK** again to close the Project Settings window. Use the File Menu and Save the ladder diagram project. The Serial Print can now be utilized from the ladder diagram project.

Printing Data to a Serial Device using a Serial Port

With the Serial Print configured in the ladder diagram project, it is now possible to use the EZ LADDER Toolkit's function blocks to serially transmit text and set points. To serial print, the SERIAL_PRINT function block is used.

Transmitting Text Serially

To transmit using the serial port, the SERIAL_PRINT function block is used. Using the SERIAL_PRINT function block is a two step process. When placing the function block, a new Serial Print Properties dialog box will open. See Figure 11-7. The *Text* field is where the message is typed that will be transmitted.


Serial Print Properties

Name: SERIAL_PRINT1

Description:

Text: I will Print this text Serially!

Figure 11-7

When all the information is entered, clicking OK will cause the function block to be placed in the ladder diagram project. Figure 11-8 is a sample of a complete SERIAL_PRINT circuit.

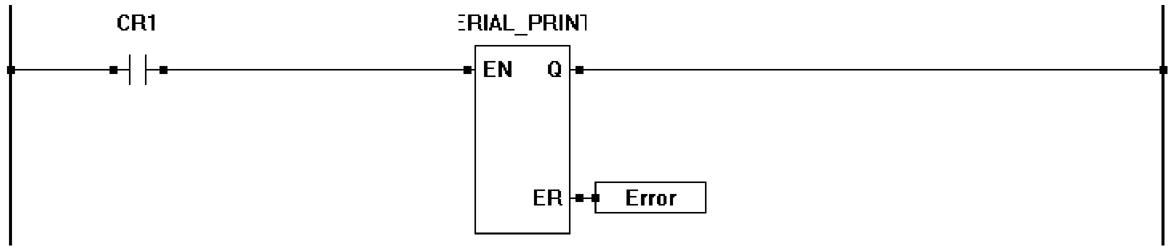
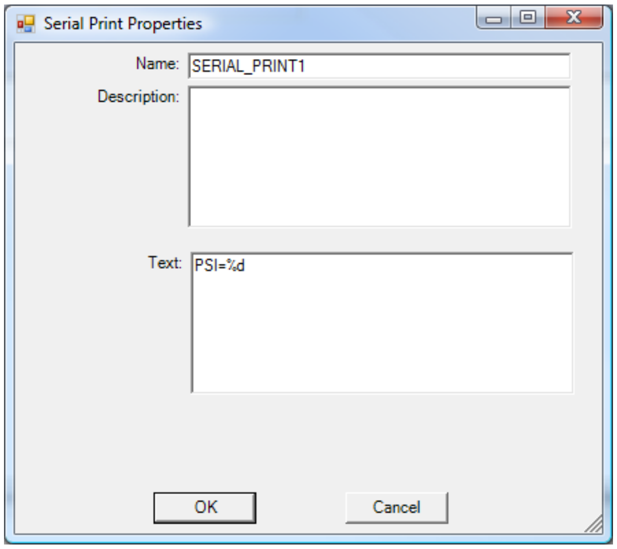


Figure 11-8

The SERIAL_PRINT function block supports special control characters. See the SERIAL_PRINT function block in **Chapter 24 - Function Reference**.

Transmitting Variables Serially

In addition to transmitting static text, it is often desirable to be able to transmit variables to another device. To transmit a variable using the serial port, the same SERIAL_PRINT function block is still used. As in transmitting text, the text is entered into the *Text* field. In addition to the text, *control characters* may be inserted that represent variables and how to format the variable text. For a full listing of what control characters and formatting is supported, please see the SERIAL_PRINT function block in **Chapter 24 - Function Reference.** Figure 11-9 illustrates a sample text dialog with control characters.



Name: SERIAL_PRINT1
Description:
Text: PSI=%d

Figure 11-9

When a SERIAL_PRINT function is used to transmit variables, a new variable input is added to the function block automatically for each variable that will be transmitted.

The SERIAL_PRINT function block is rising edge sensitive. Therefore, it will only transmit one time as the ENable input goes high. If data is required to be transmitted repeatedly, it must be programmed into the ladder diagram project as part of the ENable control on the SERIAL_PRINT function block.

Every placement of a SERIAL_PRINT function block will use available RAM. For most ladder diagram projects, there is an more than enough RAM; however, ladder diagram projects with heavy memory usage functions could run short on RAM.

For more detail on all EZ LADDER Toolkit Function Blocks and objects, refer to **Chapter 24 - Function Reference**.

Additional Serial communications is available using Modbus and Structured Text. For Modbus Master / Slave, see **Chapter 13 - Modbus Networking**. For Structured Text, see **Chapter 26 - Structured Text**.

CHAPTER 12

Real Time Clock

This chapter provides basic information to understand how to install, configure and use the Real Time Clock in the EZ LADDER Toolkit.

Chapter Contents

Installing the Real Time Clock

P-Series targets (targets based on P-Series PLC on a Chip™) support the use of a Real Time Clock device. Most P-Series based targets support an on-chip Real Time Clock. Additional real time clock devices may be connected via an SPI port on the PLC on a Chip™.

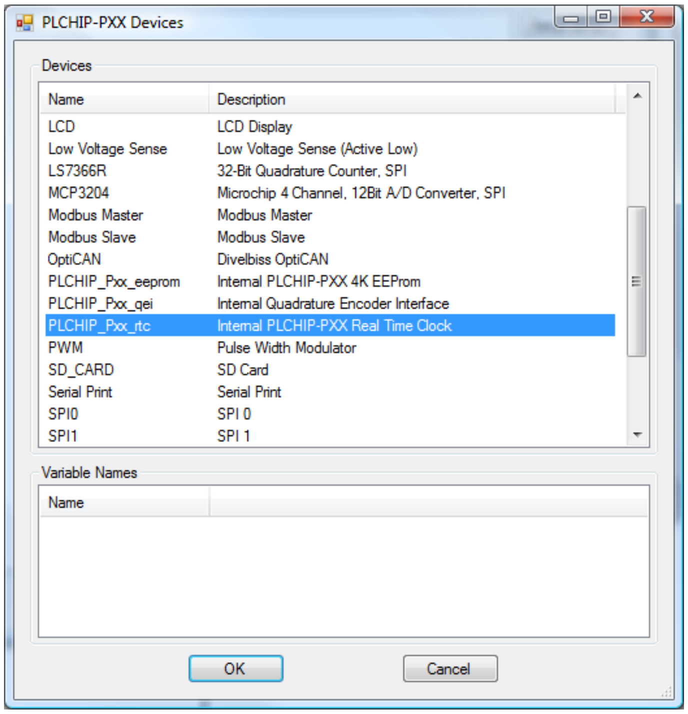
Real Time Clock support is target dependent. The PLC on a Chip™ target itself supports on-board and SPI real time clock devices. Refer to other target's user manuals or **Chapter 23 - Hardware Tar gets** for targets that support the real time clock. For proper operation the real time clock requires a battery and crystal. Standard product P-Series targets will include the battery and crystal as part of the product. When using the PLC on a Chip™ itself, the battery and crystal must be provided external to the chip itself.

Prior to using the Real Time Clock in EZ LADDER Toolkit, the Real Time Clock must be installed and configured in the target.The Real Time Clock is configured using the Project Settings.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If the real time clock were installed, it would be listed in the *Devices pane* under the Internal section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open.

All the available devices and features for the target are shown in the Devices section. Scroll down and find the PLCHIP_Pxx_rtc. Figure 12-1 shows the Target's Devices window.



Name	Description
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0
SPI1	SPI 1

Figure 12-1

Select the **PLCHIP_Pxx_rtc** and click OK. The real time clock will install and the Target's Devices window will close returning to the Target Properties Window. The real time clock will now be listed in the Devices pane. Refer to Figure 12-2.

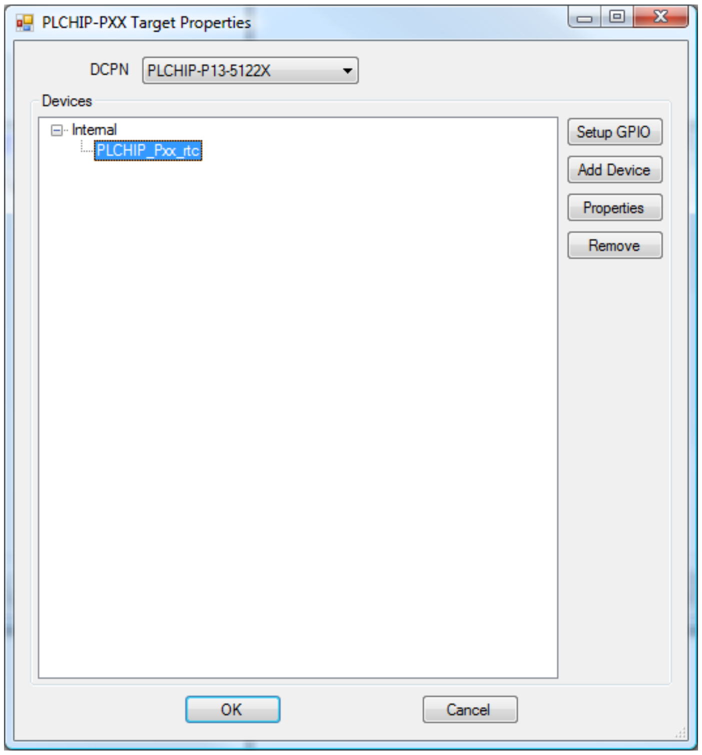


Figure 12-2

There are no additional configuration or setup required to use the real time clock. Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The real time clock is now ready to be used in the ladder diagram.

Using the Real Time Clock

To use the real time clock in a ladder diagram project, four function blocks are provided. Two blocks (GET-DATE and GETTIME) are used to read the current date and time from the real time clock. The remaining two blocks (SETDATE and SETTIME) are used to actually set the date and time on the real time clock. Figure 12-3 represents a ladder diagram program that will read the date and time.

The real time clock date and time may also be synced to a connected computer using EZ LADDER Toolkit. See the Target Utilites section in **Chapter 4 - Configuring Targets**.

The real time clock function blocks use variables as inputs (for setting date and time) and outputs for reading date and time. These integer variables are global and may be used anywhere in the ladder diagram. Figure 12-4 represents a ladder diagram to set the date and time.

For more details on using the real time clock function blocks or additional function blocks, see **Chapter 24 - Function Reference.**

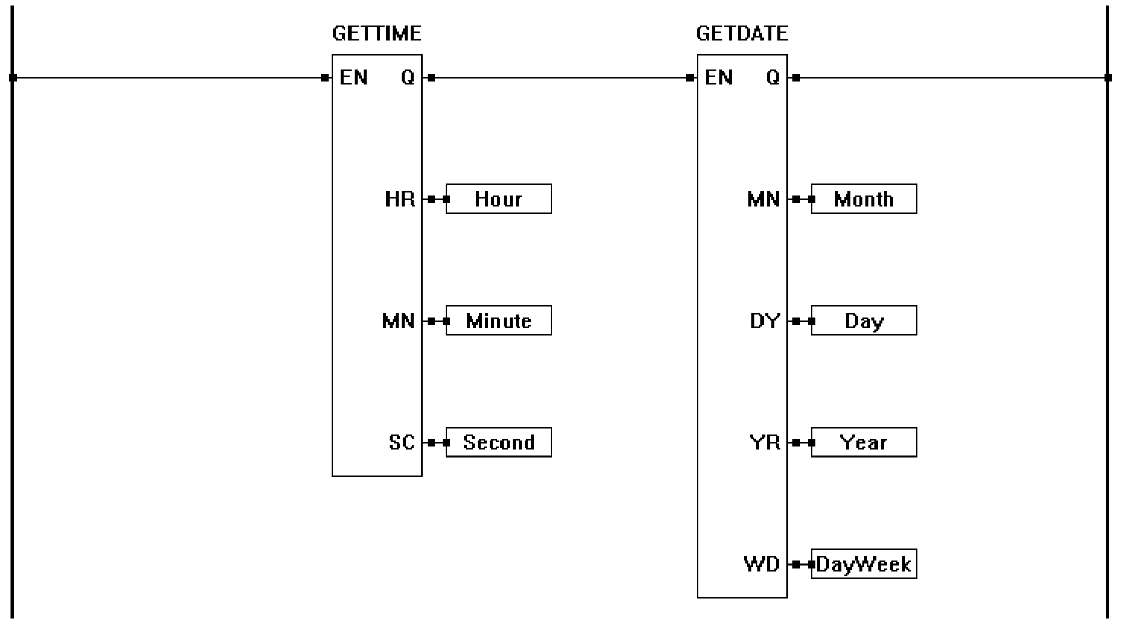


Figure 12-3

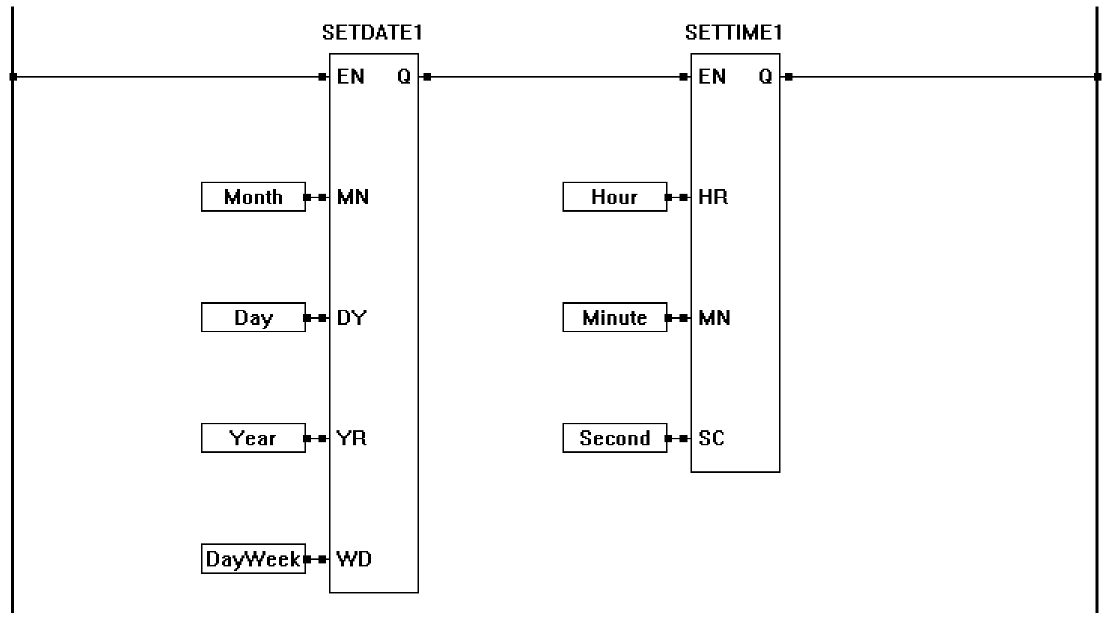


Figure 12-4

CHAPTER 13

Modbus Networking

This chapter provides basic information to understand how to install, configure and use the Modbus Networking feature in the EZ LADDER Toolkit.

Chapter Contents

Modbus Overview

Modbus is a register based communication protocol connecting multiple devices to a single network. Devices on this network are divided into two types: Master and Slave. There is only one *master* device on a network. The master is in control and initiates communication to all the other devices. Each device that is not a master must be a *slave*. Multiple slaves may be located on a network. Slave devices *listen* for communication from the master and then respond as they are instructed. The master always controls the communication and can communicate to only one or all of the slaves. Slaves can not communicate with each other directly.

All modbus networking requires either a serial port (UART) or Ethernet port for the network traffic. The network device (UART or Ethernet) must be installed prior to installing and using any Modbus devices in EZ LADDER Toolkit. For UART installation, see **Chapter 11 - UARTS and Serial Ports**. For Ethernet, see **Chapter 19 - Ethernet**.

Installing the Modbus Master

EZ LADDER Toolkit (P-Series based products) supports Modbus Master. With Master support, any of the P-Series targets may be used as a master on a modbus network.

All Modbus communciation availability is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if Modbus (and what network hardware) is supported.

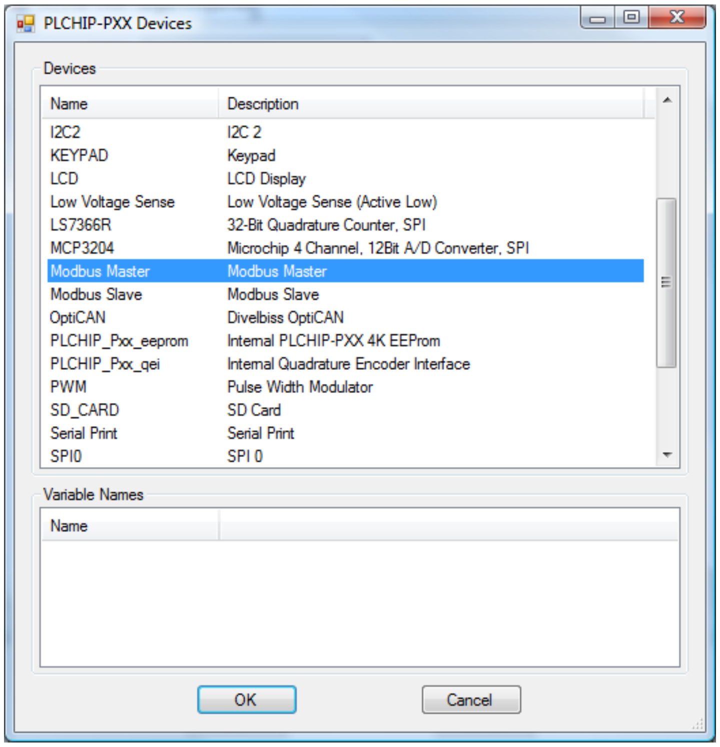
Prior to using the Modbus Master in EZ LADDER Toolkit, it must be installed and configured in the target. The Modbus Master is configured using the Project Settings.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If the Modbus Master were installed, it would be listed in the *Devices pane* under the Network section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open.

All the available devices and features for the target are shown in the Devices section. Scroll down and find the Modbus Master. Figure 13-1 shows the Target's Devices window.

Select the **Modbus Master** and click **OK**. The *Modbus Master Properties* dialog will open. This dialog is used to specify which hardware interface will be used for this Modbus Network (UARTx, Ethernet). Click the **ADD** button. The *Add Interface* dialog will open. Using the drop-down Interfade menu, select the actual hardware interface to use (UART or Ethernet must already be installed prior to this step). Enter the **Response Timeout** in milliseconds and if a UART is used, select the **Uart Properties** as RTU or ASCII based on your needs. See Figure 13-2.


PLCHIP-PXX Devices

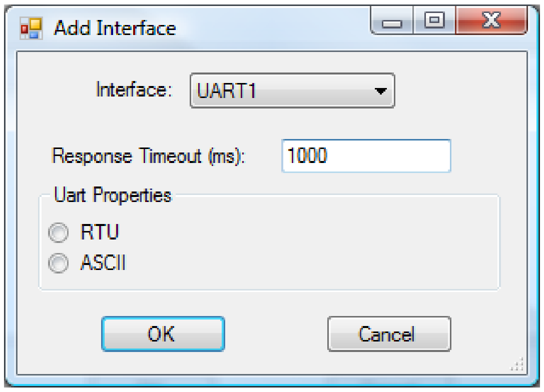
Devices

Name	Description
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0

Variable Names

Name

Figure 13-1


Add Interface

Interface: UART1

Response Timeout (ms): 1000

Uart Properties

RTU

ASCII

Figure 13-2

Click OK to close the Add Interface dialog and click OK to close the Modbus Master Properties dialog and return to the Target Properties window. The Modbus Master is now listed in the Devices pane under the Network Section. See Figure 13-3.

The Modbus Master Properties dialog and Add Interface dialogs may also be used to adjust settings and change the actual hardware interface by selecting the Modbus Master in the Devices pane and clicking the Properties button.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The Modbus Master is now ready to be used in the ladder diagram.

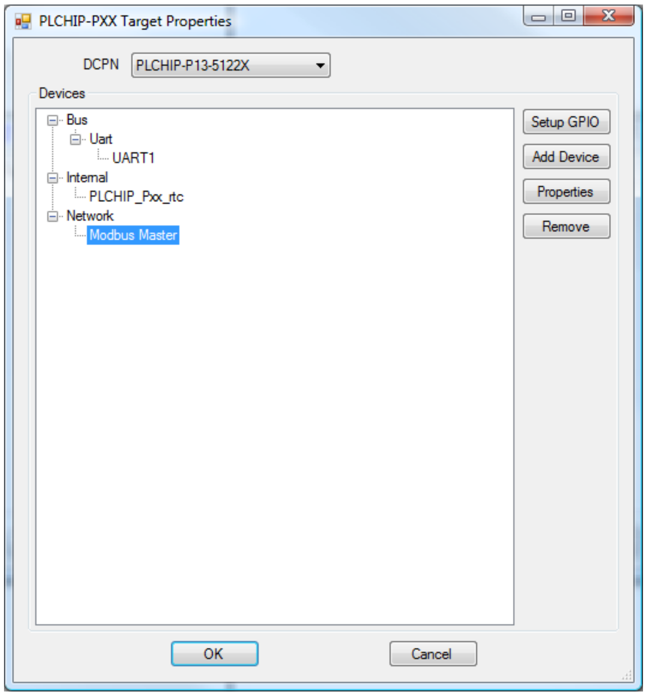


Figure 13-3

Using the Modbus Master

The Modbus Master for the P-Series initiates communications to modbus slave(s) by using the **MOD-BUS_MASTER** function block. This section is provided as a base for how to use the Modbus Master on the network, not as a modbus tutorial. Previous knowledge of Modbus would ease the integration of a modbus network.

The Modbus Master feature in EZ LADDER Toolkit supports multiple commands for network control. EZ LADDER Toolkit variables are used by the MODBUS_MASTER function block as the data storage for values using in the network communications. When values are read from slave(s), these values are stored in variables that are predefined in each instance of the MODBUS_MASTER function block. When values are to be written to slave(s), the values to be written are captured from variables that are predefined in each instance of the MODBUS_MASTER function block.

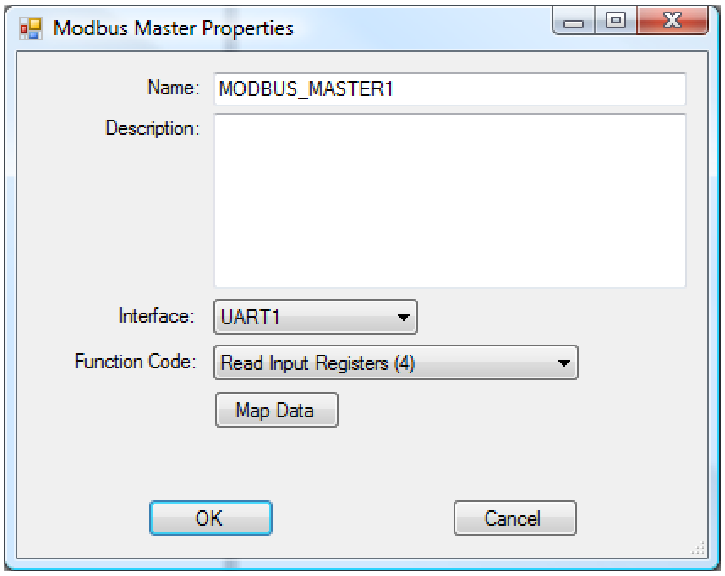
Only certain Modbus Master functions (commands) are supported in EZ LADDER Toolkit. See Figure 13-4.

Functional Description	Function #	Functional Description	Function #
Read Coils	1	Write Multiple Coils	15
Read Discrete Inputs	2	Write Multiple Registers	16
Read Holding Registers	3	Read / Write Multiple Registers	23
Read Input Registers	4		

Figure 13-4

When the MODBUS_MASTER is place in the ladder diagram workspace, a Modbus Master Properties dialog box is automatically displayed. See Figure 13-5.

Like most functions, a description can be added to the function block. Using the ***Interface*** drop-down selection menu, select the interface for the Modbus Master network (the UART or Ethernet) that was installed and configured previously. The ***Function Code*** drop-down selection box is used to select the type of function (command) for this instance of the MODBUS_MASTER function block to execute when active. These are listed in Figure 13-4. Select the Function Code and Interface as required. See Figure 13-5.


Modbus Master Properties

Name: MODBUS_MASTER1

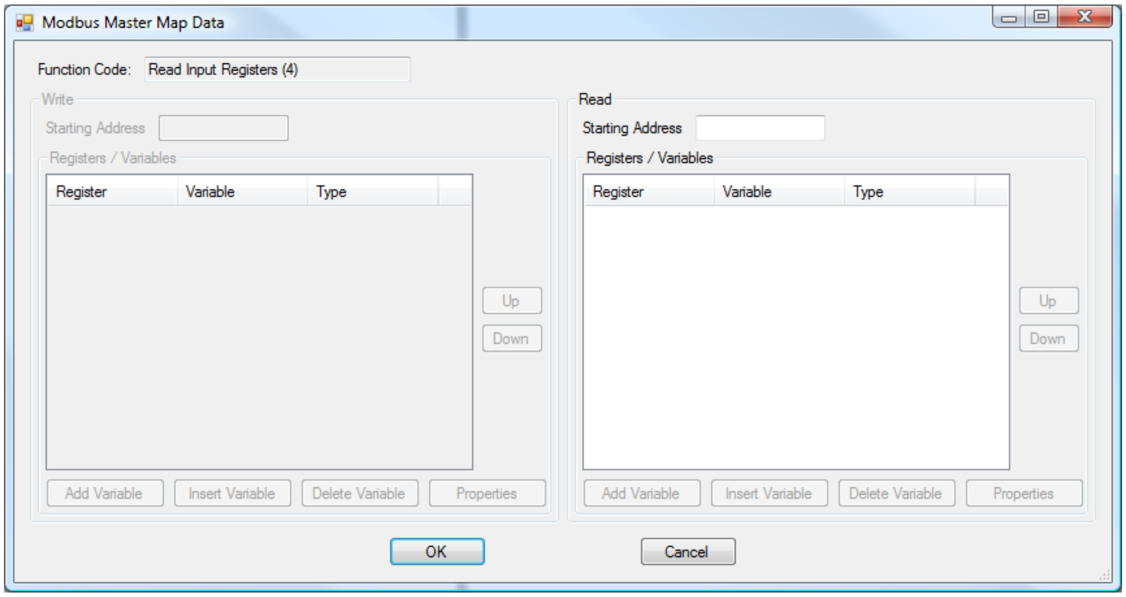
Description:

Interface: UART1

Function Code: Read Input Registers (4)

Figure 13-5

With the Interface and Function Code set, it is now time to specify the variables used for this function block to capture values and send to the slave or read values from the slave and store to. To configure the variables on this function block instance, click the **MAP DATA** button. The *Modbus Master Map Data* window will open. See Figure 13-6.


Modbus Master Map Data

Function Code: Read Input Registers (4)

Write

Starting Address

Registers / Variables

Register	Variable	Type

Read

Starting Address

Registers / Variables

Register	Variable	Type

Figure 13-6

The *Modbus Master Map Data* window is divided into two sections: **Write** and **Read**. One or both of the window sections will be active depending upon what actual Function Code was selected in the *Modbus Master Properties* dialog.

The Write and Read sections are configured identically, with the main difference that the Write section is where variables are identified that will be used as the source point for writing to slave(s); while the Read section is where variables are identified that will be used to store data read from slave(s).

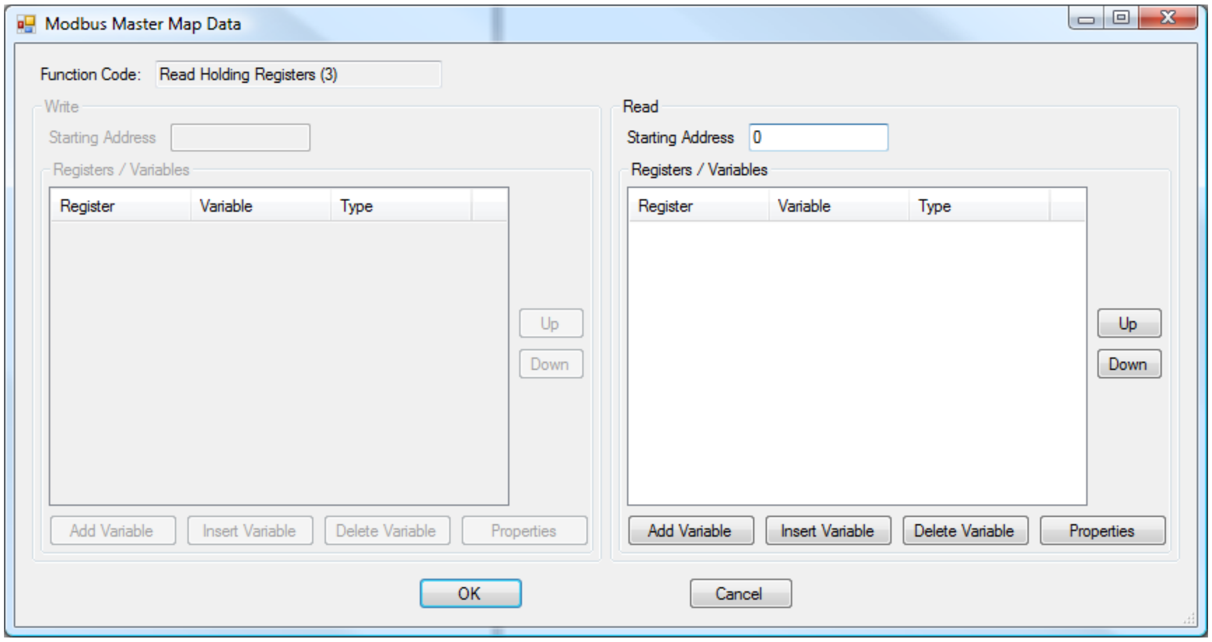
Starting Address

The Starting Address box for both the Read and Write sections is the base register number where data will be read from / written to.

The register assignments for the Modbus Master is based on the Modbus specification and thus the starting address is 0 based. Register 0 will always be the first available register in any group of registers for a Function Code type (command). Each Function Code (command) type, per the Modbus specification support registers from 0 to 65535 and the register groups for each Function Code are independent. For example, Function Code 4 (Read Input Registers) will support from 0 to 65535 registers and Function Code 3 (Read Holding Registers) will support from 0 to 65535 registers; however, these two groups of registers are unique and independent from each other.

The actual number of registers supported on slave devices may vary by implementation of the Modbus specification on the devices. See the device's documentation for actual supported sizes.

Enter the register address in the **Starting Address** box. Once a valid address is entered, several buttons and the Registers / Variables pane becomes active. See Figure 13-7.


Modbus Master Map Data

Function Code: Read Holding Registers (3)

Write: Starting Address: (blank)

Read: Starting Address: 0

Figure 13-7

Adding / Specifying Variables

The buttons in the pane are used to Add, Insert, Delete, Edit and change the order of the variables for the MODBUS_SLAVE function block.

Add Variable:	Used to add a new variable to the Registers / Variables list. Always adds the variable to the end of the currently listed variables.
Insert Variable:	When a variable is highlight in the list, this button will insert a variable above the current selection.
Delete Variable:	Deletes the hightlighted variable in the list.
Properties:	Shows the highlighted variable's properties and allows it to be changed.
Up:	Moves the hightlighted variable up in the list by one (1).
Down:	Moves the hightlighted variable down in the list by one (1).

Click the **ADD VARIABLE** button to add a new variable to the list. The *Add Variable* dialog will open. Click the **BROWSE** button. See Figure 13-8. The *Variables* window will open. Variables can be added or selected here just as was shown in **Chapter 5 - Creating Ladder Diagrams**.

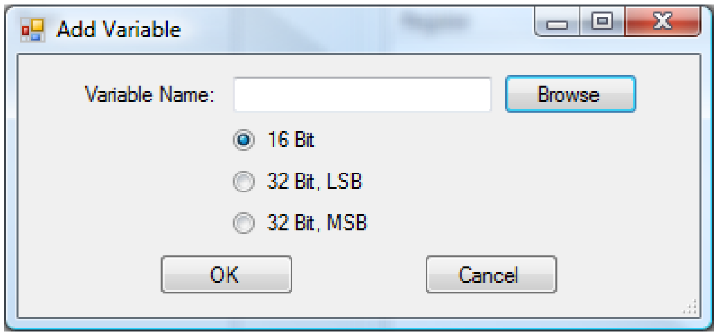


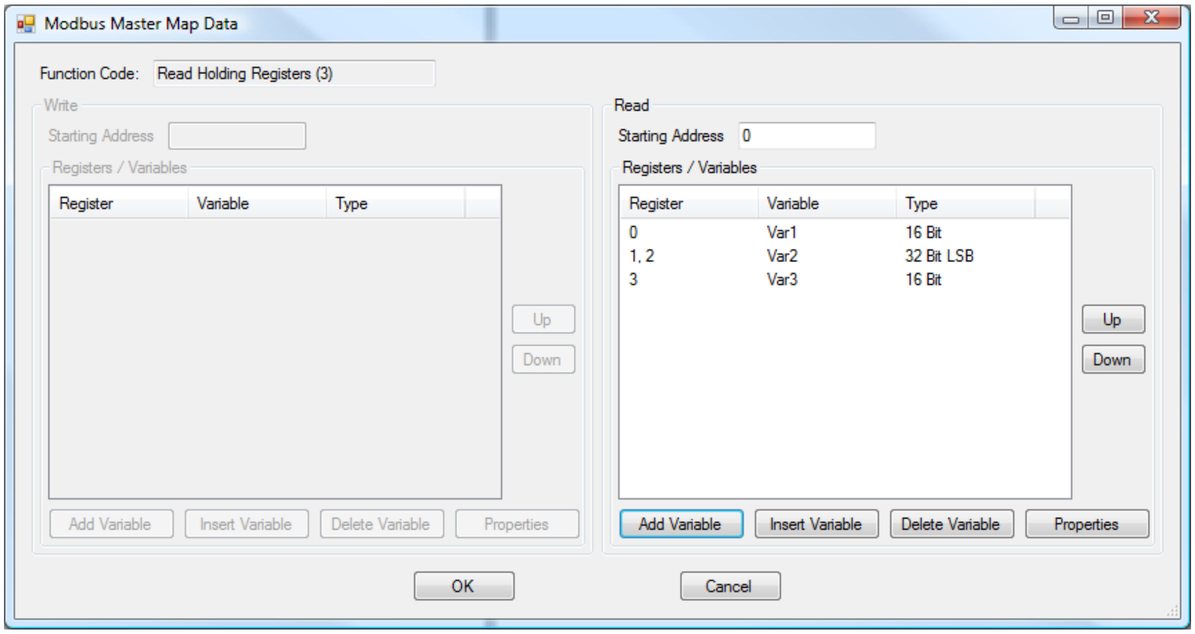
Figure 13-8

Add a new variable or select a variable from thelist of variables in the *Variables* window and click **OK**. This new or selected variable will be transferred to the *Add Variable* Dialog and the *Variables* window will close. In the Add Variable dialog, select the type of variable to write or read: 16 bit, 32 Bit LSB (ordered Least Significant Bit) or 32 Bit MSB (oredered Most Significant Bit). 32 bit variables will use multiple registers while 16 bit variables use one.

The type of variable to read / write will be entirely application dependent and slave device dependent on supported types.

Once the variable has been added or selected and the type is set, click **OK**. The *Add Variable* dialog will close and the variable selected / added will now be listed in the *Registers / Variables* pane. Repeat the steps to add addtional variables as needed for the application and this function block instance. As per indicated, the provided buttons allow the re-ordering of the variables.

Figure 13-9 illustrates 3 variables loaded, two 16 bit and one 32 bit. the types and actual registers that will be read / written to are displayed in the list with the variables.



Function Code: Read Holding Registers (3)

Read — Starting Address: 0

Register	Variable	Type
0	Var1	16 Bit
1, 2	Var2	32 Bit LSB
3	Var3	16 Bit

Figure 13-9

Click OK to close the *Modbus Master Map Data* window and click OK to close the *Modbus Master Properties* dialog. One instance of the MOSBUS_MASTER function block is now placed in the ladder program.

For each variable added, memory (RAM) is used. Large numbers of registers / variables will reduce the overall memory available for general ladder diagram object and program. Care should be taken to limit variables to only those needed.

As a MODBUS_MASTER function block supports only one Function Code (command), additional function block instances may need to be placed based on the application.

Understanding MODBUS_MASTER Function Block

The MODBUS_MASTER function block has two inputs (EN and ID) and two outputs (Q and ER). These inputs and outputs are all that are required to use the MODBUS_MASTER function block.

EN:	Function block Enable Input. The EN is active on rising edge only. A rising edge on EN enables the function block to begin communications.
ID:	Slave ID Input. This number is the number of the slave ID that this function block communicates to. A valid address is 1 to 255.
Q:	Q Output. Only goes high for one scan when the communication initiated by the EN rising edge is completed or a timeout has occured.
ER:	Error Output. Ouputs an integer number for the status of any errors detected during the communications initiated by the rising edge on EN. Zero indicates NO errors. See the MODBUS_MASTER Function Block Errors section of this chapter for a list of error codes.

When the EN rising edge is detected, the function block will attempt communication with the slave device. If an error occurs (including if the device is already busy or another MODBUS_MASTER function block is already communicating), the error will be present on the ER output. If an error occurs, the communication must be re-attempted in the ladder program as it is not buffered. While a function block is active, it's ER output will be set to 1. Figure 13-10 represents a ladder program using the MODBUS_MASTER function block.

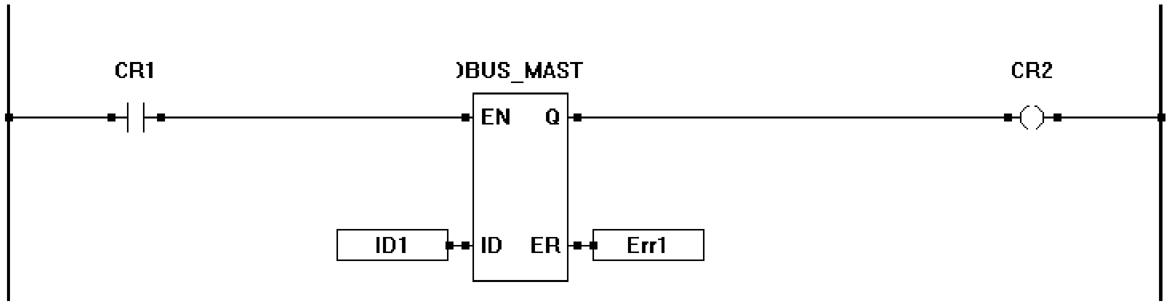


Figure 13-10

MODBUS_MASTER Function Block Errors

The MODBUS_MASTER function block provides an error (ER) output to identify errors detected during Modbus Master communications to slave devices. Figure 13-11 lists the supported error ID codes.

Error ID Code	Title	Description
0	No Error	No error was detected during communication.
1	Exception Code Illegal Function	The function code was not allowed by the slave.
1	Client Busy	A communications request is in process, busy.
2	Exception Code Illegal Data Address	The data address was not allowed by the slave.
3	Exception Code Illegal Data Value	A data value was not allowable for the slave.
4	Exception Code Slave Device Failure	An unrecoverable error occured while the slave was attempting to perform the requested function.
5	Exception Code Acknowledge	The slave has accepted the request, but it will take a long duration ot time to to complete.
6	Exception Code Slave Device Busy	The slave is processing a long duration command / function.
8	Exception Code Memory Parity Error	A Parity error was detected in memory during a attempt to read a record file.
10	Exception Code Gateway Path Unavailable	For Gateways only. Gateway was unable to allocate an internal communication path from the input port to the output port for processing the request.
11	Exception Code Gateway Target No Response	For Gateways only. Indicates no response was received from the target device.
-1	Client Receive Packet Error	An error was detected when receiving a packet from a slave
-2	Client Timeout Waiting for Response	A timeout occurred while waiting for slave response.
-3	Client Error Transmitting Packet	A error occurred transmitting a packet to a slave.
-4	Client Invalid Request	The request was not valid.
-5	Client Buffer Error	An error ocurred access the communcations buffer.
-6	Client Invalid State	The client's current state is not valid.
-7	Client Connect Failed	Unable to connect to the slave.
-8	Client Checksum Error	A checksum error occured.
-9	Client Null Transport	A Null transport pointer was detected.

Figure 13-11

Modbus Slave

EZ LADDER Toolkit provides the ability to add Modbus slave functionality to a ladder diagram (making the device a Modbus Slave).

Modbus Slave support is based on actual hardware target specifications. PLC on a Chip™ Integrated Circuits and Modules support Modbus Slave as well as do some standard Divelbiss PLCs and Controllers.. For PLCs and controllers, refer to the supported features. See **Chapter 23 - Hardware Targets**.

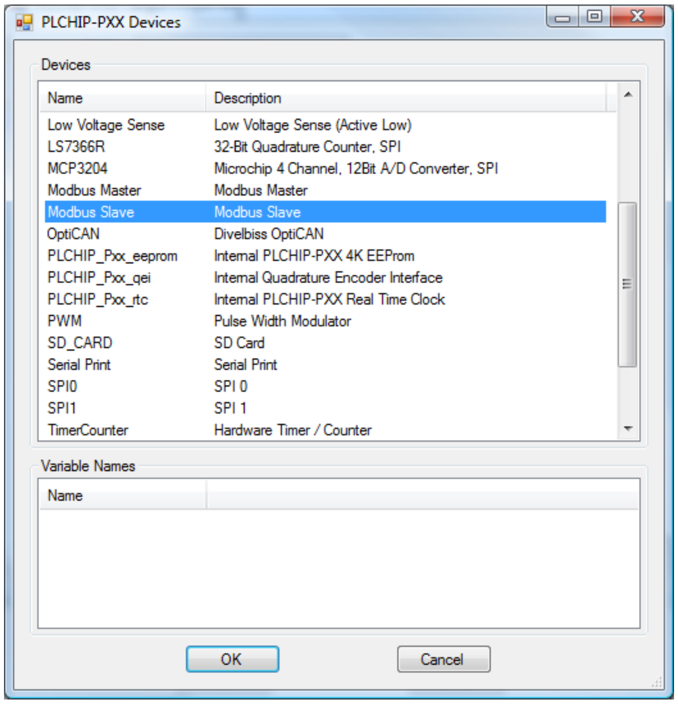
Configuring for Modbus Slave

Prior to using the Modbus Slave in EZ LADDER Toolkit, it must be installed and configured in the target.The Modbus Slave is configured using the Project Settings.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If the Modbus Slave were installed, it would be listed in the *Devices pane* under the Network section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open.

All the available devices and features for the target are shown in the Devices section. Scroll down and find the Modbus Slave. Figure 13-12 shows the Target's Devices window.

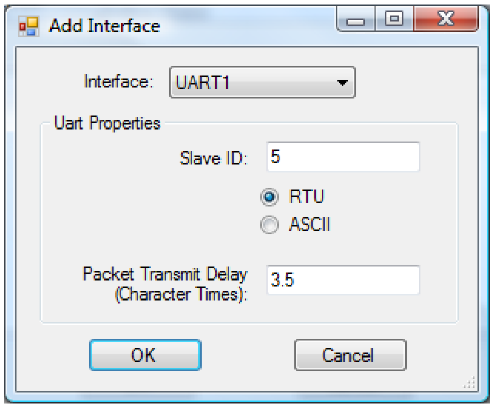


Name	Description
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0
SPI1	SPI 1
TimerCounter	Hardware Timer / Counter

Name	

Figure 13-12

Select the **Modbus Slave** and click OK. The *Modbus Slave Properties* dialog will open. This dialog is used to specify which hardware interface will be used for this Modbus Network (UARTx, Ethernet). Click the ADD button. The *Add Interface* dialog will open. Using the drop-down Interfade menu, select the actual hardware interface to use (UART or Ethernet must already be installed prior to this step). Enter the **Slave ID** of this unit (1-255), select the **Uart Properties** as RTU or ASCII based on your needs. See Figure 13-13. The packet Transmit Delay defaults to 3.5 and typically it does not need to be adjusted.


Add Interface

Interface: UART1

Uart Properties

Slave ID: 5

[✓ RTU] ASCII

Packet Transmit Delay (Character Times): 3.5

Figure 13-13

Each device on a Modbus network must have a unique ID number. Duplicate ID numbers will result in a malfunctioning network and communication errors.

Click OK to close the Add Interface dialog and click OK to close the Modbus Slave Properties dialog and return to the Target Properties window. The Modbus Slave is now listed in the Devices pane under the Network Section. See Figure 13-14.

The Modbus Slave Properties dialog and Add Interface dialogs may also be used to adjust settings and change the actual hardware interface by selecting the Modbus Slave in the Devices pane and clicking the Properties button.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The Modbus Slave is now ready to be used in the ladder diagram.

For all P-Series targets, the actual register numbers are always base zero per Function Code (Master Function Code) supported. When a modbus master queries a slave, the function code is identified and then the appropriate bank or block of registers are accessed. Register 0 will always be the first available register in any group of registers for a Function Code type (command). Each Function Code (command) type, per the Modbus specification support registers from 0 to 65535 and the register groups for each Function Code are independent. For example, Function Code 4 (Read Input Registers) will support from 0 to 65535 registers and Function Code 3 (Read Holding Registers) will support from 0 to 65535 registers; however, these two groups of registers are unique and independent from each other.

Typically the following register types are supported: Coils, Discrete Inputs, Inputs, and Holding Registers. Using these groups of registers, a master can read and write as needed for communication.

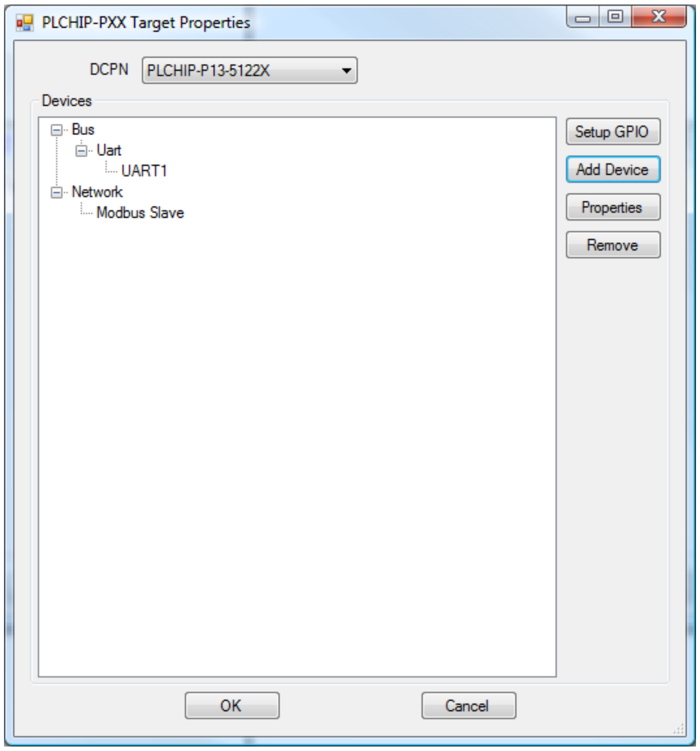


Figure 13-14

Coil Registers

Coils registers are registers that are written to by the Master. Using these registers, the master can directly control coils located in the ladder diagram project (internal only).

Discrete Input Registers

Discrete Input registers are registers that are read directly by the Master. Using these registers, the master can directly monitor the status of contacts located in the ladder diagram project (internal or real world).

Input Registers

Input registers are registers that may be read by the Master, but can only be written to by the slave itself. Using these registers, the slave can set data that the master can view, but not modify.

Holding Registers

Holding registers are registers that may be read and modified by both the Master and Slave. These are the most commonly used registers to pass data between the master and slave.

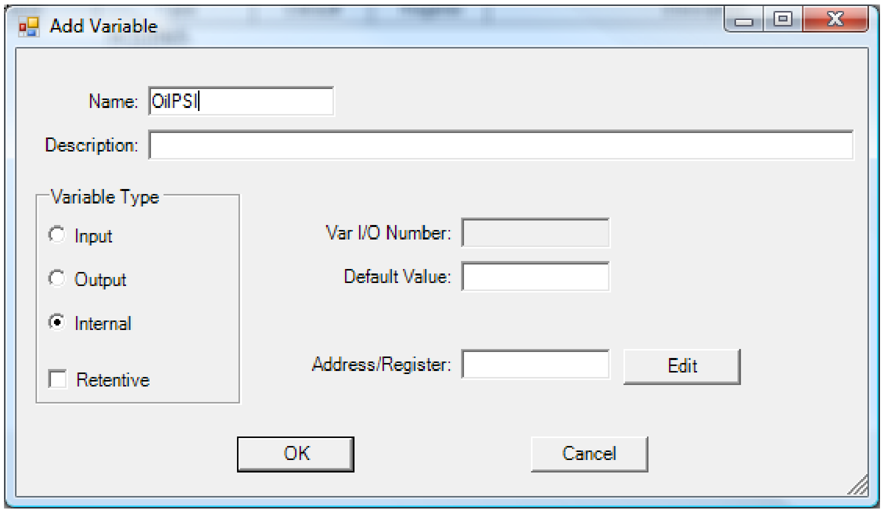
All Modbus registers are accessed as variables and must begin with *MB_* to identify a modbus slave register.

Assigning and Setting Slave Registers

To use Modbus Slave registers, registers must be assigned to variables. For more information regarding variables, refer to **Chapter 5 - Creating Ladder Diagram Projects**. Modbus registers can be assigned by editing an existing variable when new variables are created.

Coils and Discrete Input registers are to be used with Boolean variable types while Holding and Input Registers are typically used with Integer variables.

To assign a Modbus register to a variable, using the Add Variable or Edit Variable dialog, click the **EDIT** button next to the Address / Register field. See Figure 13-15.



Name: OilPSI
Description:
Variable Type: Internal

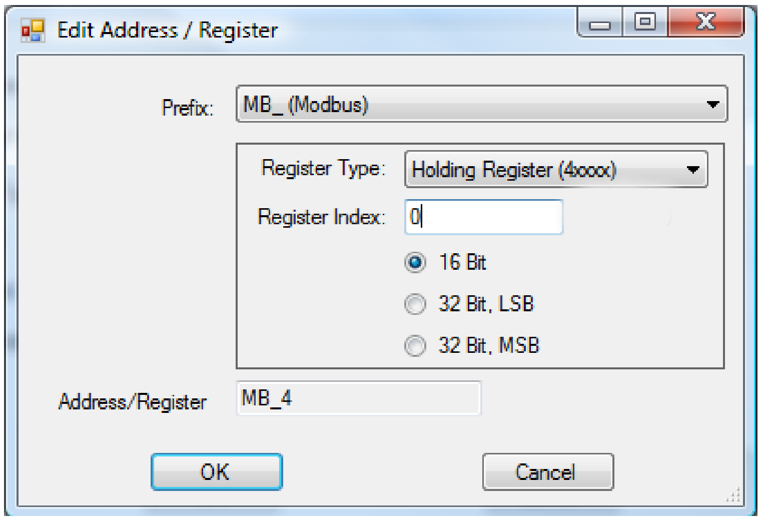
Figure 13-15

The Edit Address / Register dialog box will open. See Figure 13-16. Using the drop down menu, select ***MB_(Modbus)***. From the now visible Register Type drop down box, select the type of register to use (of the four supported types). In the Register Index box, type the address number of the modbus register (0-65535). This number depends on the type of register and it's range of allowed register numbers.

As the register type is selected and the number entered, the Address / Register displayed will be updated immediately. The MB_ and Function code is automatically entered. Only the actual register number needs to be added. This register number is always between 0 and 65535. This register number is automatically added to the MB_ Xand type to create the register number in the correct range.

Select the type of variable to write or read: 16 bit, 32 Bit LSB (ordered Least Significant Bit) or 32 Bit MSB (oredered Most Significant Bit). 32 bit variables will use multiple registers while 16 bit variables use one.

Click **OK** to close the Edit Address / Register dialog box and return to the Add/Edit Variable dialog box. The register address is transferred to the text box automatically. Click **OK** to save the variable. The register is now assigned to a variable.



Prefix: MB_ (Modbus)
Register Type: Holding Register (4xxxx)
Register Index: 0
16 Bit [✓]
32 Bit, LSB
32 Bit, MSB
Address/Register: MB_4

Figure 13-16

A Modbus address may be directly typed into the Address / Register box without using the **EDIT** button.

Updating Network and Variable Values

When network registers are assigned to variables, any change to the variable locally in the ladder diagram project is available to the master to see without additional programming. If the master chooses to view the register, it will see the variables current value.

If the master chooses to modify a register (if the type is allowed to be modified), then any changes made by the master to the register will immediately change the value of the variable that is assigned to that register and will be used in the ladder diagram project locally.

Modbus Slave Communication Errors

Modbus communications supports the use of error codes to identify and diagnose problems with the network and slaves. These errors are reported on master only. Typical error codes are:

2 - Illegal Data Address	This identifies that the master attempted to access an invalid register.
3 - Illegal Data Value	This identifies the master attempted to access a register that is valid but not used in the ladder diagram project (on the slave unit).The largest register number is kept automatically by EZ LADDER Toolkit in the ladder diagram project.

For more details regarding errors and error codes on a Modbus Network, refer to the network Master's documentation.

Modbus Slave - Supported Master Functions

EZ LADDER Toolkit's Modbus Slave supports eight standard Modbus master functions (functions the master can use to access and update slave registers). While there is no way for the ladder diagram or EZ LADDER to use these functions, they are noted for reference.

Supported Functions include:

1 - Read Coil Status
2 - Read Discrete Input Status
3 - Read Holding Registers
4 - Read Input Registers
5 - Write to a Single Coil
6 - Write to a Single Register
15 - Write to Multiple Coils
16 - Write to Multiple Registers

For more details regarding master functions and how to use them, refer to the network Master's documentation.

Modbus TCP over Ethernet

In addition to supporting Modbus Master and Slave via UART(s) or Serial Ports, the P-Series based targets also support Modbus TCP over Ethernet.

Modbus TCP over Ethernet support is based on actual hardware target specifications. PLC on a Chip™ Integrated Circuits and Modules support Modbus Slave as well as do some standard Divelbiss PLCs and Controllers. For PLCs and controllers, refer to the supported features. See **Chapter 23 - Hardware Targets**.

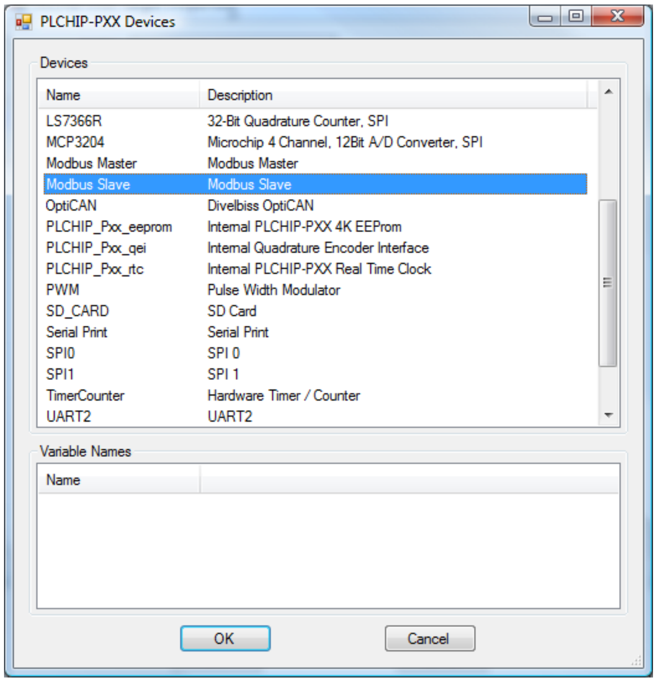
Configuring for Modbus TCP over Ethernet

Prior to using the Modbus TCP over Ethernet in EZ LADDER Toolkit, it must be installed and configured in the target.The Modbus TCP is configured using the Project Settings.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If the Modbus were installed, it would be listed in the *Devices pane* under the Network section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open.

All the available devices and features for the target are shown in the Devices section. Scroll down and find the Modbus Slave or Modbus Master depending upon your exact needs. Figure 13-17 shows the Target's Devices window.

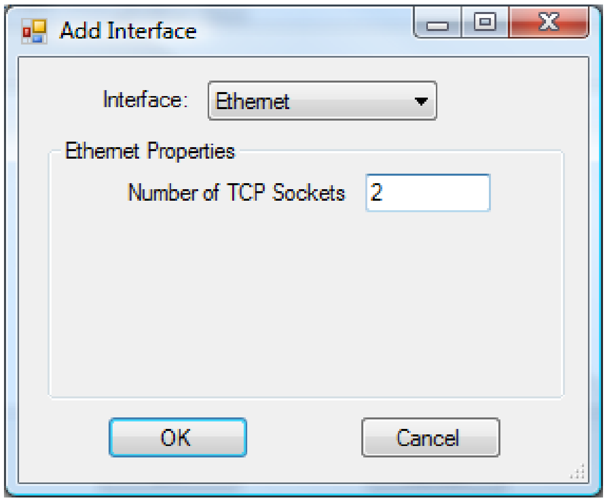


Name	Description
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0
SPI1	SPI 1
TimerCounter	Hardware Timer / Counter
UART2	UART2

Figure 13-17

For this example select the **Modbus Slave** and click OK. The *Modbus Slave Properties* dialog will open. This dialog is used to specify which hardware interface will be used for this Modbus Network. Click the ADD button. The *Add Interface* dialog will open. Using the drop-down Interfade menu, select the actual hardware interface: Ethernet. The Ethernet must already be installed prior to this step. Enter the **Number of TCP Sockets** based on your needs. See Figure 13-18. For details on installing Ethernet, see **Chapter 19 - Ethernet**.

If Modbus Master was selected, the Number of TCP Sockets is not available, but the Response Timeout will need to be configured.



Interface: Ethernet

Number of TCP Sockets 2

Figure 13-18

Click OK to close the Add Interface dialog and click OK to close the Modbus Slave Properties dialog and return to the Target Properties window. The Modbus Slave is now listed in the Devices pane under the Network Section.

The Modbus Slave Properties dialog and Add Interface dialogs may also be used to adjust settings and change the actual hardware interface by selecting the Modbus Slave in the Devices pane and clicking the Properties button.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The Modbus Slave TCP over Ethernet is now ready to be used in the ladder diagram.

The Slave ID is not set in the Modbus Slave Project Settings when using Modbus TCP over Ethernet. The slave ID is set using the MODBUS_SET_PROPERTY function block in the ladder diagram project.

Modbus using Multiple Ports

The structure of the EZ LADDER Toolkit and P-Series hardware targets allow for modbus to be implemented using multiple ports that include serial ports and ethernet. As an example, two serial ports may be configured to be Modbus slaves with unique *slave ID* numbers or one serial port may be configured as a slave and the ethernet port may be configured to use Modbus TCP.

Regardless of the configuration, all the modbus registers are universal; meaning all the ports may use exactly the same register numbers (each port does not have individual register sets). This allows for multiple devices to access the same register and variable and therefore share the same data easily.

If the data in registers must be unique to each port, then the network registers must be mapped and divided based on register numbers on a per port basis. Using variables for each mapped network register section per port will allow this separate values to be accessed by the ladder variables (based on register number).

CHAPTER 14

CAN Networking

This chapter provides basic information to understand how to install, configure and use the OptiCAN Networking, J1939 Networking and NMEA 2000 Networking feature in the EZ LADDER Toolkit.

Chapter Contents

What is CAN?

CAN is short for Controller Area Network. CAN networks use a two-wire backbone to provide communication to each individual item on the network. There are specific requirements for the hardware, see the OptiCAN section of this chapter.

CAN networking refers to the hardware. There are multiple CAN protocols for communicating between devices on a CAN network. As with all networking and protocols, protocols have advantages and disadvantages. Some common protocols are: SAE J1939, CANopen, etc.

At this time the P-Series based targets only support the proprietary OptiCAN protocol.

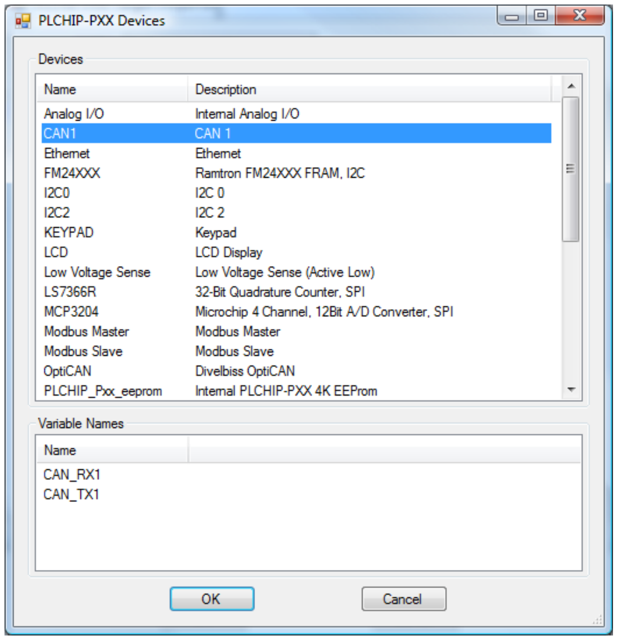
Installing CAN Network Ports

Prior to installing and configuring any type of CAN protocol, the actual CAN port must installed in the P-Series target.

CAN Networking Port availability is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if CAN Network Ports are supported.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the PROPERTIES button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If any CAN port were installed, it would be listed in the *Devices pane* under the Bus\CAN section. Click the ADD DEVICE button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the CAN ports (CAN0, CAN1, etc). Figure 14-1 shows the Target's Devices window.



Name	Description
Analog I/O	Internal Analog I/O
CAN1	CAN 1
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm

Variable Names

Name
CAN_RX1
CAN_TX1

Figure 14-1

Select **CANx** and click OK. The Target's Devices window will close and the previous target properties window will now list the CAN port as an installed device.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The CAN port is now installed and ready to be used in the ladder diagram.

Baud Rate and other communication configuration items are controlled by the network protocol (ie: OptiCAN) and do not require configuration anywhere else.

Divelbiss OptiCAN Network

OptiCAN is a Divelbiss proprietary CAN (Controller Area Network) that provides a communication link between Divelbiss OptiCAN enabled controllers and other OptiCAN enabled controllers and devices such as I/O modules. The Divelbiss OptiCAN network supports up to 64 nodes (devices) and is register based. Each node supports up to 256 registers and communication can be triggered based on time or on an event.

Divelbiss OptiCAN can perform the following major functions:

1. Allow controllers to access external I/O Devices
2. Allow controllers to access other controllers
3. Allow the user to configure devices utilizing the CAN protocol

Only Divelbiss OptiCAN enabled devices will communicate on the network OptiCAN network. Connecting non-OptiCAN devices will result in network errors including loss of communication.

Planning the OptiCAN Network

As with any network or communication scheme, the network should be planned taking into account the amount of communication, broadcast rate, communication triggers, register assignments and timing requirements. This plan is essential for a successful implementation of a network.

It is suggested that register needs should be identified and assigned for each device prior to the start of the programming. While any legal register may be used, it is recommended that register assignments start at the high end of available registers and work backward (i.e.: start with register 127 and then assign 126 and so on). As some devices utilize lower register numbers this will ensure that the controller register assignments will not interfere with the device register assignments.

All OptiCAN controllers have the ability to *broadcast* (send data) and *listen* (receive data). OptiCAN Controllers broadcast to all units (called *nodes*) on the network. This is called a *Global Broadcast*.

While all controllers may broadcast and listen, ideally one should be identified as a controlling agent for the network. This agent controller should be responsible for the network commands that start, stop and reset the OptiCAN network communications.

Hardware Requirements & Recommendations

For optimal functionality, performance and noise immunity, all the hardware recommendations must be followed. A failure to follow recommended hardware requirements could result in decreased reliability of the OptiCAN Network.

Please adhere to the following requirements and recommendations:

1. The OptiCAN network cable should be of a *twisted pair with shield* variety and cannot exceed 40 meters in total length. Additional length or incorrect cable type may limit functionality or cause the network to fail.

   Please adhere to the following specifications for cable requirements for all OptiCAN networks.

Twisted Pair Shielded Cable Specifications						
Parameter	**Symbol**	**Minimum**	**Nominal**	**Maximum**	**Unit**	**Comments**
Impedance	Z	108	120	132	Ω	
Specific Resistance	r_b	0	25	50	mΩ/m	
Specific Capacitance	C_b	0	40	75	pF/m	Between Conductors
	C_s	0	70	110	pF/m	Conductor to Shield

2. A 120Ω ohm resistor (load) is required at each end of the network.

   Please adhere to the following specifications for terminating resistor requirements for all OptiCAN networks.

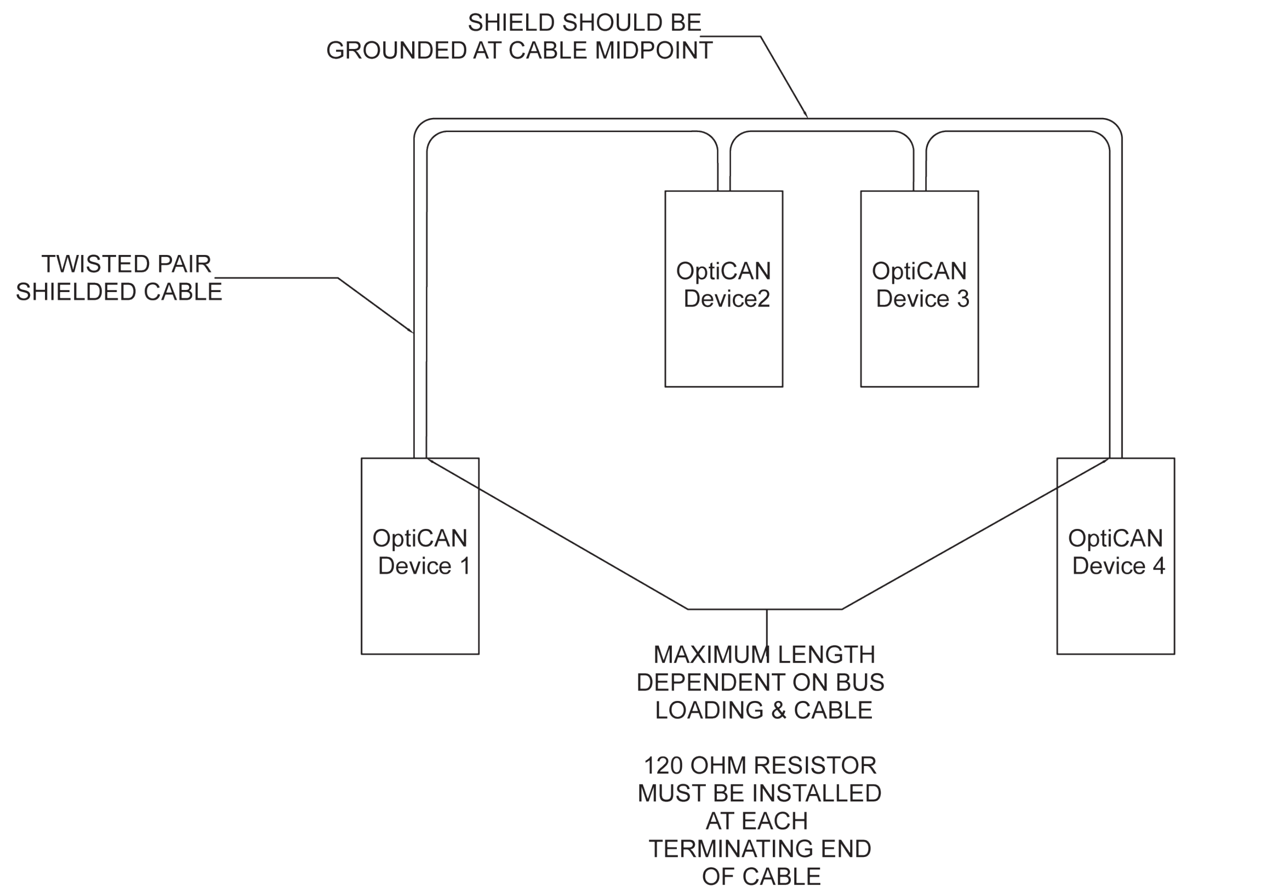
Terminating Resistor Specifications						
Parameter	**Symbol**	**Minimum**	**Nominal**	**Maximum**	**Unit**	**Comments**
Resistance	R_L	110	120	130	Ω	Min power dissipation 400mW(1)
Inductance				1	µh	
(1) Assumes a short of 16V to V_{CAN_H}						

3. The cable shield should be grounded near the middle of the network (cable) run.

   The shield should only be connected to ground and one point on the network. Multiple ground points could cause a ground loop, decrease noise immunity and adversely affect network performance.

4. If wiring as a network bus with stub connections, the maximum stub length from bus to node is 1 Meter.

   See Figure 14-2 for a sample connection diagram.


SHIELD SHOULD BE
GROUNDED AT CABLE MIDPOINT
TWISTED PAIR
SHIELDED CABLE
OptiCAN
Device2
OptiCAN
Device 3
OptiCAN
Device 1
OptiCAN
Device 4
MAXIMUM LENGTH
DEPENDENT ON BUS
LOADING & CABLE
120 OHM RESISTOR
MUST BE INSTALLED
AT EACH
TERMINATING END
OF CABLE

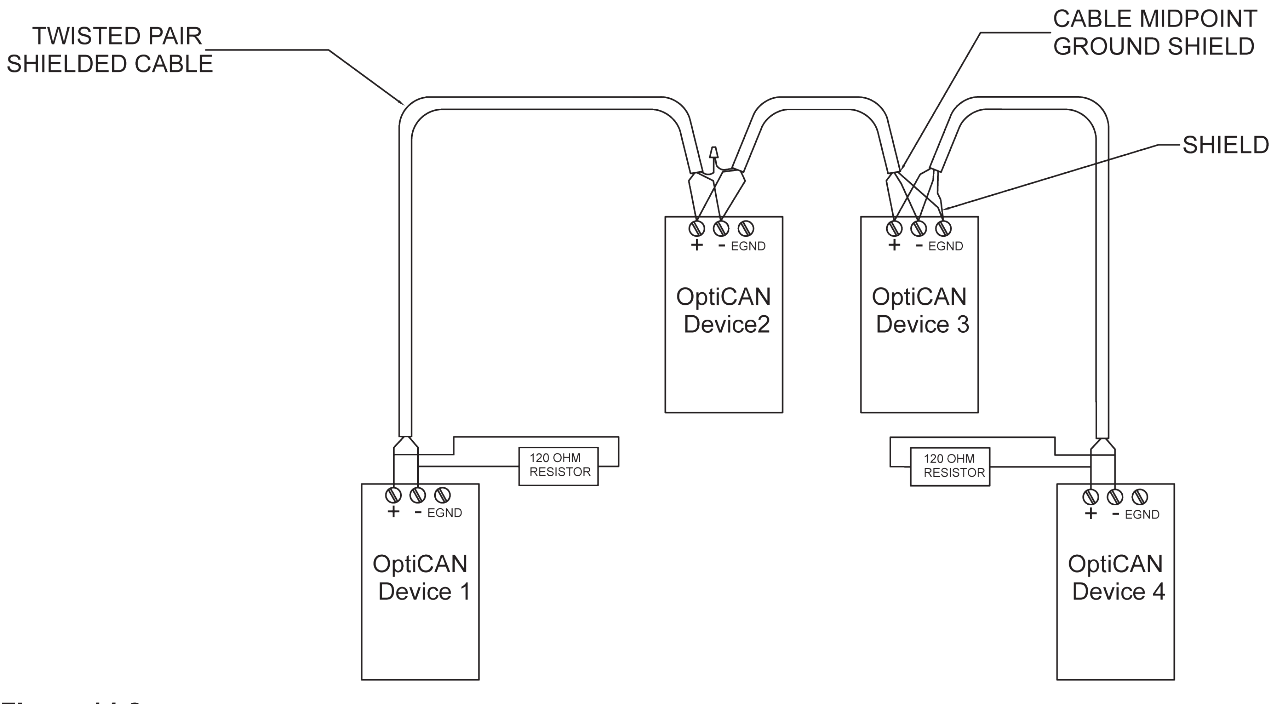

TWISTED PAIR
SHIELDED CABLE
CABLE MIDPOINT
GROUND SHIELD
SHIELD
+ - EGND
OptiCAN
Device2
OptiCAN
Device 3
120 OHM
RESISTOR
OptiCAN
Device 1
OptiCAN
Device 4

Figure 14-2

OptiCAN Specifications

Bandwidth:	250 KBits / Sec
Maximum Cable Length:	Up to 270 Meters [1]
Maximum Number of Nodes:	Up to 254 Nodes [1]
Registers per Node:	256 Registers

[1] Dependent on cable selection and bus loading. See Application Note for CAN Transceiver (NXP AN00020 or your CAN transceiver)

Using Controllers on the OptiCAN Network

A typical application involves a controller running it's own ladder diagram project, monitoring inputs and controlling outputs based upon the project that is running. When connected to an OptiCAN network the controller will operate the same, but now using OptiCAN, it can communicate to other devices including other controllers with OptiCAN and OptiCAN I/O Modules.

The following describes how a controller can operate when used on a active OptiCAN network.

1. Local Control: Monitor Inputs and Control Outputs
2. Globally *broadcast* data to all OptiCAN Nodes on the OptiCAN Network
3. *Listen* for Broadcasts from a specific Node on the OptiCAN Network

All EZ LADDER Toolkit programmed OptiCAN network controllers are configured using the EZ LADDER Toolkit and maintain their network settings, parameters and register settings in the actual ladder diagram project. Each controller on the OptiCAN Network may have different settings and all will be required to have a different Node ID (address).

OptiCAN Controller Heartbeat

Each OptiCAN controller has the ability to broadcast a signal called a *heartbeat*. This signal is broadcast at a regular interval and is used to ensure that all devices on the network are communicating properly. Each node automatically listens for this heartbeat and adjusts OptiCAN registers based on the network condition. These conditions may be monitored using function blocks.

One node on the OptiCAN network **MUST** broadcast the heartbeat message for the network to function properly. Although it is possible to have multiple controllers on one network sending heartbeats, it is recommended only one controller broadcast a heartbeat per network.

In the event the heartbeat is lost, then the local ladder diagram project should ignore data from the network as the loss of heartbeat signifies that communication with part or all of the network has been lost. How a controller responds to a network loss is entirely dependent on the ladder diagram project.

Installing a Controller on the OptiCAN Network

Before a controller may communicate on the OptiCAN network, it must be installed in the EZ LADDER Toolkit. Once the OptiCAN settings are configured, they are stored in the actual ladder diagram project. Please see the following steps required to install and configure the OptiCAN network feature on a controller. Actual menus steps to reach the OptiCAN configuration may vary based on the actual controller used, but the configuration itself is always the same. Divelbiss standard controllers based on PLC on a Chip (Enhanced Baby Bear, PCS-XXX, etc) are configured based on the part number. For details on specific targets, please see **Chapter 23 - Hardware Targets**.

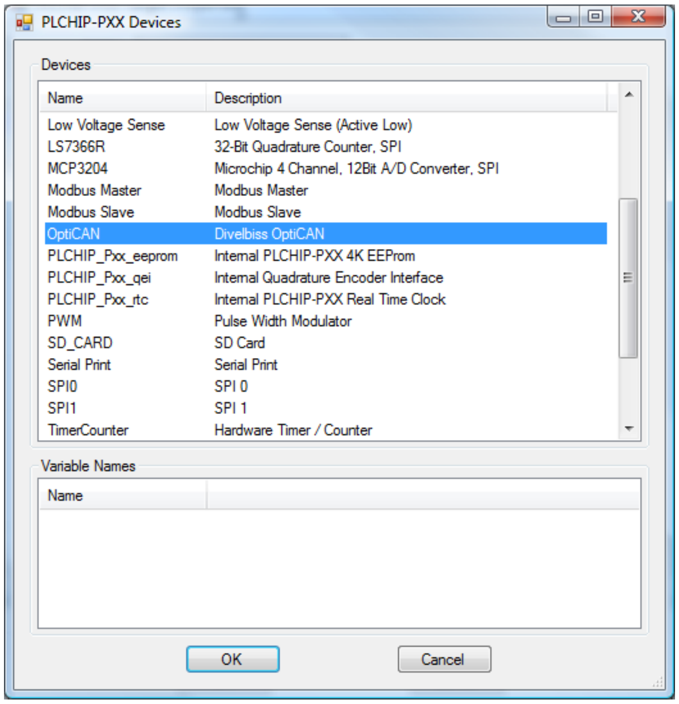
OptiCAN Networking availability is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if OptiCAN is supported.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If OptiCAN were installed, it would be listed in the *Devices pane* under the Device section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open.

A CAN port must be installed prior to installing OptiCAN. See **Installing CAN Network Ports** earlier in this chapter.

All the available devices and features for the target are shown in the Devices section. Scroll down and find the OptiCAN. Figure 14-3 shows the Target's Devices window.



Name	Description
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0
SPI1	SPI 1
TimerCounter	Hardware Timer / Counter

Figure 14-3

Select the **OptiCAN** and click OK. The *OptiCAN Properties* dialog will open. This dialog is used to specify which CAN port is to be used, the Node ID, Broadcast Rate, Heartbeat and Broadcast Register setup.

This dialog box is used to configure the controller on an OptiCAN Network. Figure 14-4 show the OptiCAN Properties dialog box. The following items must be configured:

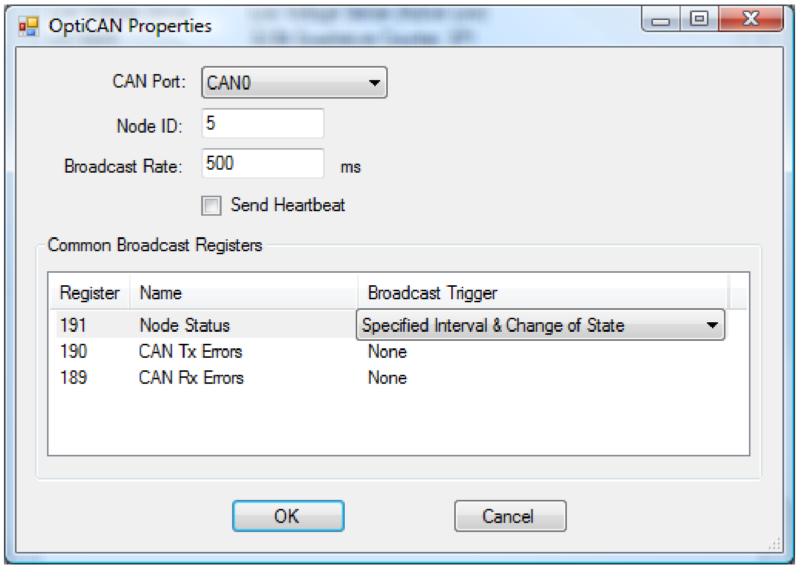
1. CAN Port — Using the drop down menu, select the physical CAN port that will be connected to the OptiCAN network. All installed and not used CAN ports are displayed.

2. Node ID — The Node ID serves as the controller's address on the network. It may be numbered up to the maximum number of nodes allowed.

   All Node IDs on an OptiCAN Network must be unique. Duplicate Node IDs will result in communication errors or communication loss.

   The node ID may also be set from the ladder diagram project using a variable. This variable must be configured as node 255. The variable (integer value) then becomes the OptiCAN node ID. It is important to keep this ID number in the proper range.

3. Broadcast Rate — The rate that the controller will broadcast registers is entered here in milliseconds. This timing requirement should be identified during network planning.



CAN Port: CAN0

Node ID: 5

Broadcast Rate: 500 ms

☐ Send Heartbeat

Common Broadcast Registers

Register	Name	Broadcast Trigger
191	Node Status	Specified Interval & Change of State
190	CAN Tx Errors	None
189	CAN Rx Errors	None

Figure 14-4

In addition to the parameters listed above that are required, the following additional configuration points are optional based on the requirements of the controller, program and network configuration.

1. Send Heartbeat — Check this box configure this controller to send a network heartbeat signal.

   ! One node on the OptiCAN network **MUST** broadcast the heartbeat message for the network to function properly. Although it is possible to have multiple controllers on one network sending heartbeats, it is recommended only one controller broadcast a heartbeat per network.

2. 191 Node Status — This setting identifies when to broadcast the status of this controller (node). The broadcast trigger may be selected by clicking in the table. The selections are Specified Interval, Change of State and Specified Interval and Change of State.

3. CAN Tx Errors — This setting identifies when to broadcast the CAN Transmit errors identified by this controller (node).The broadcast trigger may be selected by clicking in the table. The selections are Specified Interval, Change of State and Specified Interval and Change of State.

4. CAN Rx Errors — This setting identifies when to broadcast the CAN Receive errors identified by this controller (node).The broadcast trigger may be selected by clicking in the table. The selections are Specified Interval, Change of State and Specified Interval and Change of State.

When the OptiCAN properties have been configured, click OK to close the OptiCAN Properties dialog and return to the the Target Properties window. OptiCAN is now listed in the Devices pane under Device.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. OptiCAN is now installed and ready to be used in the ladder diagram.

Controller OptiCAN Network Register Assignments

The OptiCAN network operates based on preset and user defined registers. The following are general register assignments and information common for all OptiCAN enabled controllers. For non-controller devices, please consult the product's data sheet for detailed register assignments and preset functions.

General Register Assignments: These are the overall general register assignments common to all OptiCAN enabled devices.	
Register Number	**Assigned Function / Use**
0-127	User Defined Controller Registers and I/O Defined Registers
128-191	Common Broadcast Registers
192-255	Common Configuration and Command Registers

User Defined registers for controllers are available for the user to define the use of during the ladder diagram project development. Device Defined registers for I/O and other devices have preset definitions of register use and cannot be changed.

Common Configuration / Command Register Assignments: These registers are pre-assigned and cannot be altered. These register's contents may only be modified by a controller and can only change the I/O setting.			
Register Number	**Name**	**Description**	**Read / Write**
255	Node ID	The node's ID Number	Read / Write
254	Serial Number	The node's Serial Number	Read
253	Broadcast Interval	Interval for Broadcasting (ms)	Read / Write
252	Broadcast Trigger 0	Broadcast Trigger for Registers 0-15	Read / Write
251	Broadcast Trigger 1	Broadcast Trigger for Registers 16-31	Read / Write
250	Broadcast Trigger 2	Broadcast Trigger for Registers 32-47	Read / Write
249	Broadcast Trigger 3	Broadcast Trigger for Registers 48-63	Read / Write
248	Broadcast Trigger 4	Broadcast Trigger for Registers 64-79	Read / Write
247	Broadcast Trigger 5	Broadcast Trigger for Registers 80-95	Read / Write
246	Broadcast Trigger 6	Broadcast Trigger for Registers 96-111	Read / Write
245	Broadcast Trigger 7	Broadcast Trigger for Registers 112-127	Read / Write
244	Broadcast Trigger 8	Broadcast Trigger for Registers 128-143	Read / Write
243	Broadcast Trigger 9	Broadcast Trigger for Registers 144-159	Read / Write
242	Broadcast Trigger 10	Broadcast Trigger for Registers 160-175	Read / Write
241	Broadcast Trigger 11	Broadcast Trigger for Registers 176-191	Read / Write

Common Broadcast Register Assignments: These registers are pre-assigned and cannot be altered			
Register Number	**Name**	**Description**	**Read / Write**
191	Node Status	This Node's Status	Read
190	CAN Transmit Errors	CAN Transmit Error Counter	Read
189	CAN Receive Errors	CAN Receive Error Counter	Read

The Node Status register (191) is represented by a 32 bit number. The lower 16 bits represents the current **status code** while the upper 16 bits represents the **error code**.

There are three status codes supported on the OptiCAN network. The status codes are:
1 = Reset, 2 = Active, and 4 = Error.

If the error code returned is 0, then typically, the network was not started.

Error codes are divided into two groups. Device specific errors are numbered 0-32767 while common error codes are numbered 32768-65535.

Common Error Codes are as follows:

65535 = CAN Controller Receive Error	65531 = CAN Controller Bus Off State
65534 = CAN Controller Receive Warning	65530 = CAN Controller Data Overrun
65533 = CAN Controller Transmit Error	65519 = OptiCAN Heartbeat Timeout
65532 = CAN Controller Transmit Warning	65518 = CAN Controller Error

Broadcasting to Other Controllers and Devices

To broadcast from one controller to other controllers and devices, the following steps should be completed before proceeding.

1. All OptiCAN Devices and Controllers on the network must be identified with unique Node ID numbers and configured properly.

2. Register assignments and uses should be defined as these register number will be needed to broadcast and listen.

3. The heartbeat node should be identified.

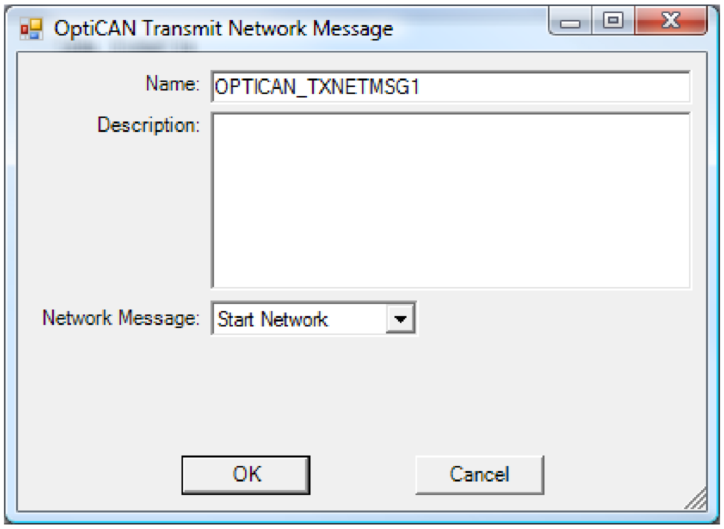
To broadcast to nodes, several steps must take place in addition to the configurations listed above. For the OptiCAN network to function correctly, several steps must be taken. Before any node can broadcast or listen, the OptiCAN Network must be *started*.

To Start the OptiCAN Network

The OPTICAN_TXNETMSG function block is used to send global network commands to all OptiCAN nodes on a network. Using this function block, a controller may send a ***Network Start***, ***Network Stop*** or a **Network Reset** command.

On power up, the OptiCAN network does NOT start by default and will not begin communication until one controller has sent the ***Network Start*** command.

To send the start command, the OPTICAN_TXNETMSG function block is used. Using the OPTICAN_ TXNETMSG function block is a two step process. When placing the function block, the OptiCAN Transmit Network Message dialog box will open. See Figure 14-5. Using the drop down menu, select the Network Message *Start Network*.


OptiCAN Transmit Network Message

Name: OPTICAN_TXNETMSG1

Description:

Network Message: Start Network

Figure 14-5

Click OK to place the function block in the ladder diagram project. Figure 14-6 is a sample of a complete OPTICAN_TXNETMSG circuit. Note the use of contacts to control when the Start Network is sent.

The Network Start should be sent based on two conditions: The network needs to start as in a start-up or if communication errors are detected. If a single node loses power, it will appear as communication loss. When node regains power, it will not communicate on the network unless another Network Start is sent (since nodes do not start on power up). If at any time a communication is lost to a node, re-send the Network Start.

Restarting upon an error is entirely application dependent. Some applications would benefit from an automatica restart while other applications may find it beneficial to stop all functions when an error is detected. Safety should be paramount when deciding when to automatically restart.

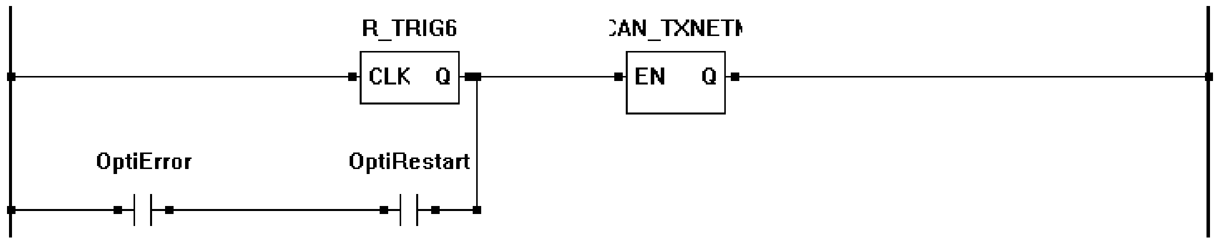


Figure 14-6

All nodes on the network should begin communication upon receipt of the Start Network command. With the network started and communicating, it is now possible to broadcast to nodes and listen for node broadcasts.

Global Broadcasting to all Nodes

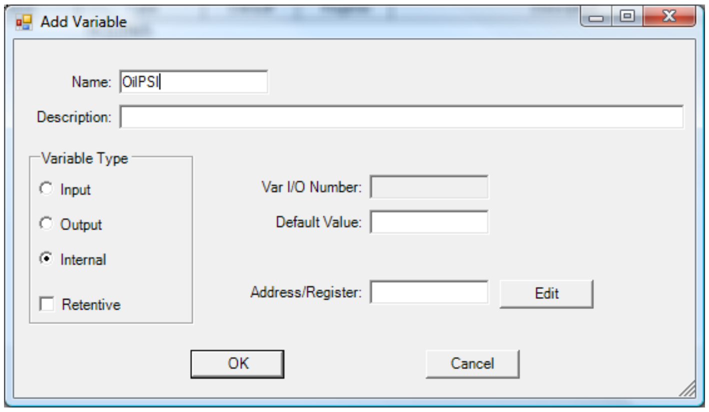
To broadcast or listen, a basic understanding of registers is required. Typically, controller registers 0-127 are available to be user-defined and used while 128-255 are pre-defined and cannot be altered. The user-defined registers are commonly used to communicate between controllers.

It is recommended that before programming is started that all nodes are identified, assigned a node ID and documented. For each device, their register requirements should be identified, registers assigned and registers documented. This will verify the all requirements are met and help to promote proper functionality and design.

To send a global broadcast, a variable must be identified and assigned to use an OptiCAN register. To assign an OptiCAN register to a variable, using the Add Variable or Edit Variable dialog, click the EDIT button next to the Address / Register field. See Figure 14-7.

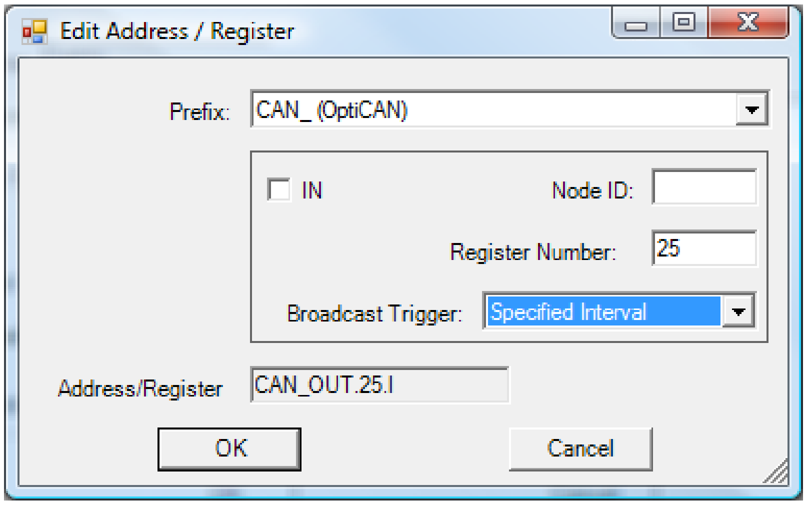
The Edit Address / Register dialog box will open. See Figure 14-8. Using the drop down menu, select ***CAN_(OptiCAN)***. Fill in the Register Number only to transmit to the same register on all nodes. The register number must be a user-defined register (0-127). When broadcasting, leave the Node ID empty or blank.

Leaving the Node ID blank causes this variable to be sent to the same register number on all nodes on the network (Global Broadcast). This method will allow for any node to have the ability to *listen* for this register broadcast.



Name: OilPSI
Description:
Variable Type: [✓ Internal]
Address/Register:

Figure 14-7



Prefix: CAN_ (OptiCAN)
IN [ ]
Node ID:
Register Number: 25
Broadcast Trigger: Specified Interval
Address/Register CAN_OUT.25.I

Figure 14-8

Using the Broadcast drop down menu, select a broadcast trigger. The choices are: None, Specified Interval, Change of State and Specified Interval and Change of State. This register will be broadcast when this condition is met. Click OK to close the dialog and click OK to close the Add / Edit Variable dialog.

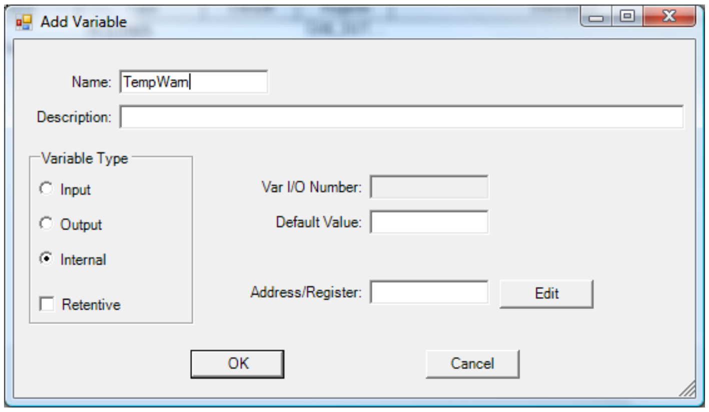
As the register type is selected and the number entered, the Address / Register displayed will be updated immediately. The CAN_ and the register number is automatically entered.

In this example, when this ladder diagram project is running, value of the variable OilPSI will be transmitted globally to all nodes at register 25. The interval will the same as Broadcast Rate that was configured in the Project Settings.

Listening for Broadcasts

While broadcasting can be global or to a specific node ID, all listening for broadcasts are specific. For a controller to listen for a broadcast, the specific node ID and register are required.

To listen for a broadcast, a variable must be identified and assigned to use an OptiCAN register. To assign an OptiCAN register to a variable, using the Add Variable or Edit Variable dialog, click the EDIT button next to the Address / Register field. See Figure 14-9.



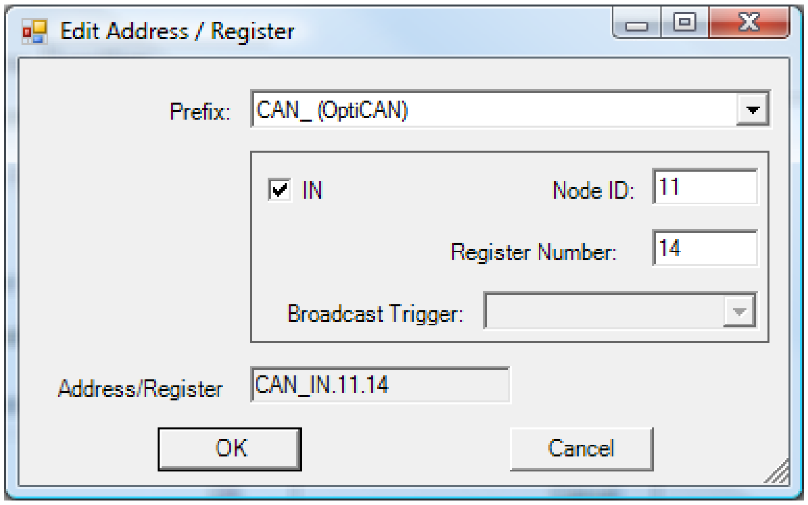
Name: TempWam
Description:
Var I/O Number:
Default Value:
Address/Register:

Figure 14-9

The Edit Address / Register dialog box will open. See Figure 14-10. Using the drop down menu, select ***CAN_(OptiCAN)***. Fill in the Node ID with the node ID number of the device you wish to listen for.

Fill in the Register Number that you are listening for on the specific node. The register number must be a user-defined register (0-127).

Click the IN check box. This identifies that this variable will be listening, not broadcasting. The Broadcast Trigger drop down is no longer available. Click OK to close the dialog and click OK to close the Add / Edit Variable dialog.



Prefix: CAN_ (OptiCAN)
IN: ✓
Node ID: 11
Register Number: 14
Broadcast Trigger:
Address/Register: CAN_IN.11.14

Figure 14-10

Leaving the node ID blank while is allowable, but is not a valid address and no data will be received.

When this ladder diagram project is running, if a broadcast from node ID 11, register 4 is seen on the network, it will be heard and the register (variable) on this controller will be updated.

Determining Node Status

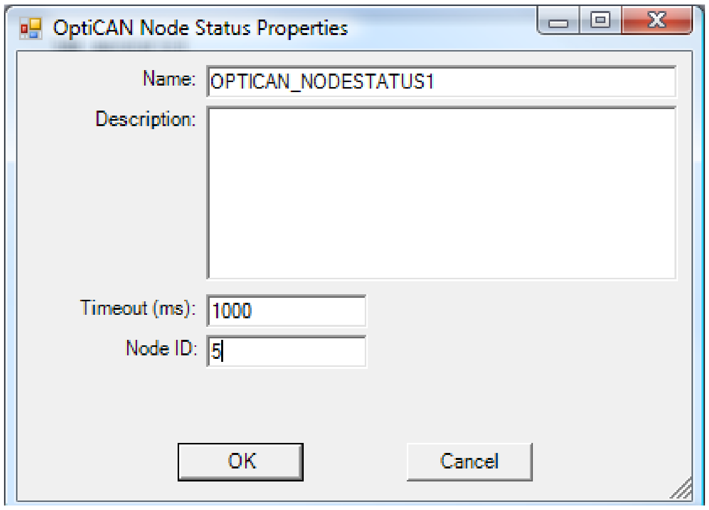
As discussed earlier in this chapter, that a Start Network command must be transmitted to start the network communicating and that it should happen on start up. In addition, it was recommended to monitor nodes status and possible resent the Start Network command in the event of a communications loss to a node.

To determine the status of a specific node, the OPTICAN_NODESTATUS function block is used. Using the OPTICAN_NODESTATUS function block is a two step process. When placing the function block, the OptiCAN Node Status Properties dialog box will open. See Figure 14-11.

In the Node ID field, enter the node ID that is to be monitored for communication loss and in the Timeout (ms) field, enter the amount of time that communication is lost before the node status is changed (in milliseconds).

When enabled, the OPTICAN_NODESTATUS block's Q output will be true if messages are received from the actual node. If the Q output is false, then the node status is not valid as no messages are received from it. When this occurs, the VAL output will be set to zero.

The OPTICAN_NODESTATUS function block is node specific, meaning that for each node that must be monitored for a network restart, a separate function block is required. In addition, nodes that are considered critical in overall operation may require multiple uses of the OPTICAN_NODESTATUS function block to identify errors and handle them correctly. Restarting or stopping based on communication errors is application dependent. Keep in mind, there will always be some communication errors on any network. The amount and type of what is allowable is application dependent.



OPTICAN_NODESTATUS1

1000

5

Figure 14-11

Click **OK** to place the function block in the ladder diagram project. Figure 14-12 is a sample of a complete OPTICAN_NODESTATUS circuit. The Error variable shown will be equal to the status of the node that was programmed into the function block. The error codes are listed earlier in this chapter.

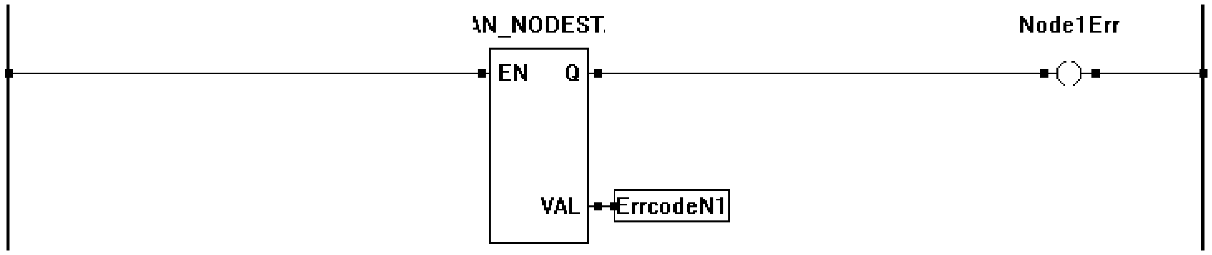


Figure 14-12

Using the OptiCAN Configuration Tool

Up to this point, we have configured controllers on the OptiCAN network. In addition to controllers, other devices support OptiCAN including I/O modules. As these devices are not programmed with an EZ LADDER Toolkit ladder diagram project, other means must be used to identify and configure them. There are two tools that may be used to configure non-controller OptiCAN devices.

The first option is to purchase the OptiCAN Configuration Tool Professional. The Professional version is sold separately and requires additional hardware (included in the purchase). The Professional version does not have a limitation on the number of nodes that may configured. In addition, it also has more advanced controls, diagnostics and reporting features. The OptiCAN Configuration Tool Professional has it's own User's Manual.

If the OptiCAN network will host more than 10 non-controller nodes, then you must purchase and use the OptiCAN Configuration Tool Professional to configure the non-controller nodes.

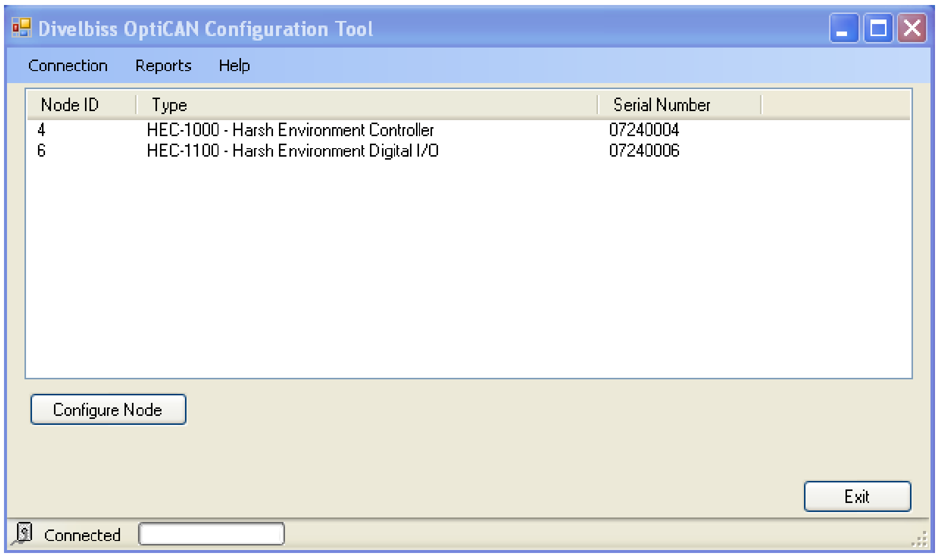
The OptiCAN Configuration Tool Basic is part of the EZ LADDER Toolkit and is capable of configuring up to 10 total non-controller nodes on an OptiCAN network. As this is a feature of the EZ LADDER Toolkit and does not require additional hardware or software, it will covered in detail.

The can detect up to 10 nodes, returning the Node ID, Device Type / Name and it's Serial Number.

To use the OptiCAN Configuration Tool, a ladder diagram project with OptiCAN enabled must be loaded, compiled and running on a target. Using EZ LADDER Toolkit, change to the Monitor Mode. In the Monitor Mode, using the ***Project Menu***, select *OptiCAN*. The Divelbiss OptiCAN Configuration Tool will open in a new window. See Figure 14-13.

EZ LADDER Toolkit must have a project loaded and be in Monitor mode (with OptiCAN enabled) to open the OptiCAN Configuration Tool. It is not necessary to connect to the target controller. If connected to the controller, the OptiCAN Configuration Tool will disconnect EZ LADDER Toolkit from the controller when it opens.

Whenever the OptiCAN Configuration tool connects, it automatically sends the Stop Network command. The network will have to be restarted for proper operation.



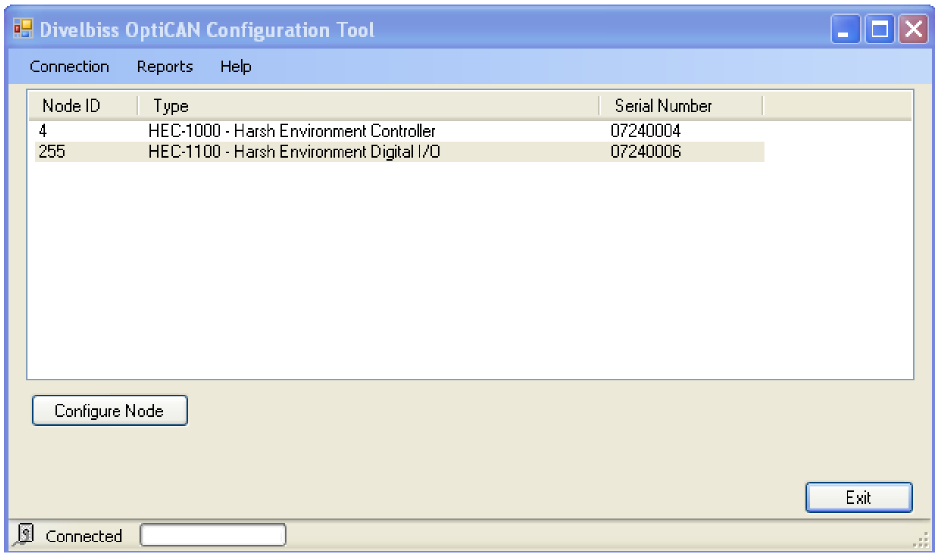
Node ID	Type	Serial Number
4	HEC-1000 - Harsh Environment Controller	07240004
6	HEC-1100 - Harsh Environment Digital I/O	07240006

Figure 14-13

As shown in Figure 14-13, there are two devices on the OptiCAN network. The tool shows the Node ID, Type and Serial Number for each of the devices. These two devices are already configured as they have Node ID's assigned.

When configuring a non-controller device for the first time, the device will display with a Node ID of 255. The 255 designation is reserved for devices that have not been configured. See Figure 14-14. For multiple new devices, they will all be assigned the same 255 Node ID. The controller can differentiate between devices that have not been configured using their serial number. The serial number is programmed at the factory and is not user changeable.

Only non-controller device Node IDs may be configured using this tool. Controller Node IDs are only changeable in the actual ladder diagram project loaded on the controller.



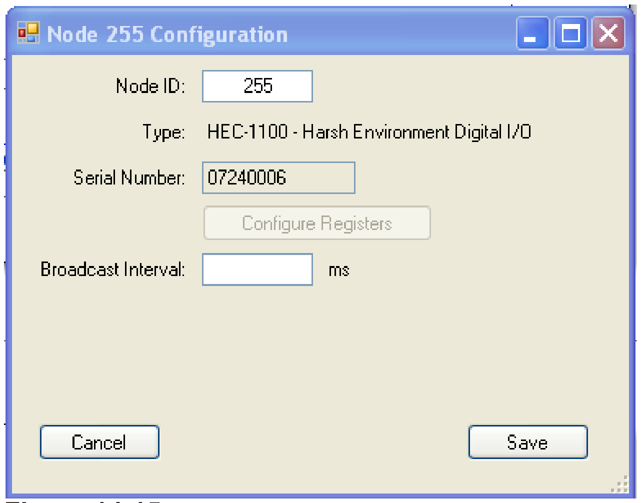
Node ID	Type	Serial Number
4	HEC-1000 - Harsh Environment Controller	07240004
255	HEC-1100 - Harsh Environment Digital I/O	07240006

Figure 14-14

To Configure a Node

To configure a node, select the node (highlight) in the list and click the **CONFIGURE NODE** button. The Node Configuration dialog box will open. See Figure 14-15. The following can be viewed from the Node Configuration dialog. Some may be configured while others may not.

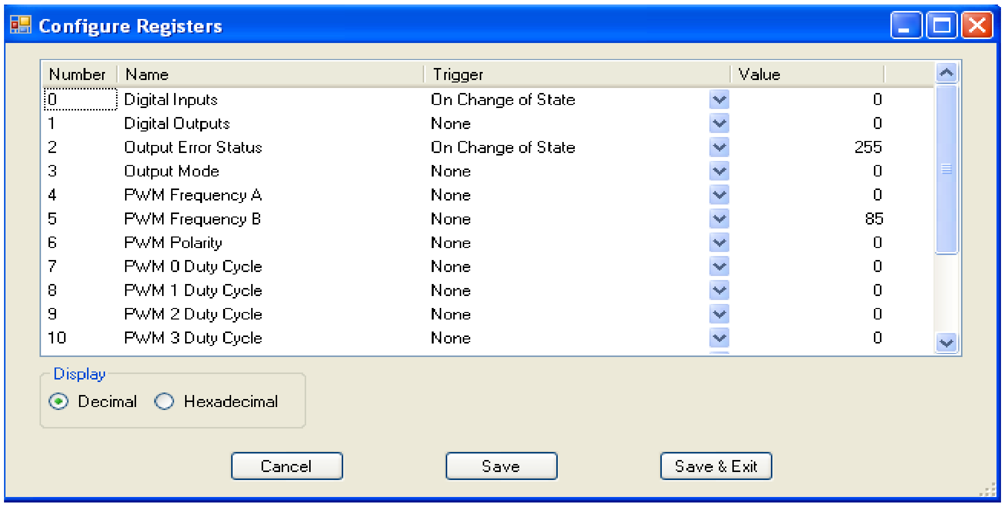
Node ID:	This is where the node ID number is set.
Type:	This is the description of the device (cannot be edited).
Serial Number:	This is the serial number of the device (programmed at factory and cannot be edited).
Broadcast Interval:	This is the interval (rate) at which the registers will be broadcast on the net work.



Node ID: 255
Type: HEC-1100 - Harsh Environment Digital I/O
Serial Number: 07240006
Broadcast Interval: ms

Figure 14-15

The **CONFIGURE REGISTERS** button is used to configure each register of the device including it's trigger and value. **CONFIGURE REGISTERS** button to open the Configure Registers dialog box. See Figure 14-16.

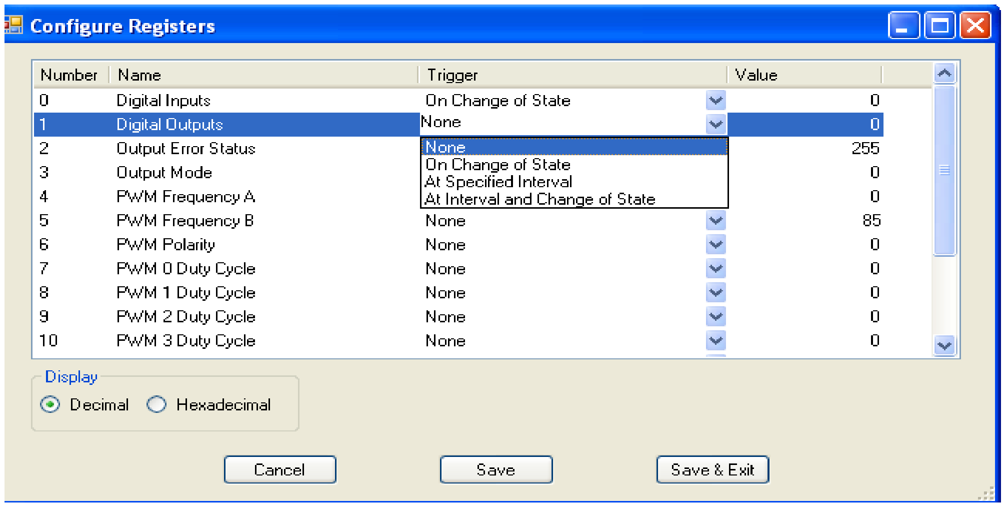


Number	Name	Trigger	Value
0	Digital Inputs	On Change of State	0
1	Digital Outputs	None	0
2	Output Error Status	On Change of State	255
3	Output Mode	None	0
4	PWM Frequency A	None	0
5	PWM Frequency B	None	85
6	PWM Polarity	None	0
7	PWM 0 Duty Cycle	None	0
8	PWM 1 Duty Cycle	None	0
9	PWM 2 Duty Cycle	None	0
10	PWM 3 Duty Cycle	None	0

Display: [✓ Decimal] Hexadecimal

Figure 14-16

To change the Trigger for any register, select the register and click the down arrow in the trigger column for that register. This will open a small list of trigger options. Each register maintains its own individual trigger setting. See Figure 14-17.



Number	Name	Trigger	Value
0	Digital Inputs	On Change of State	0
1	Digital Outputs	None	0
2	Output Error Status		255
3	Output Mode		0
4	PWM Frequency A		0
5	PWM Frequency B	None	85
6	PWM Polarity	None	0
7	PWM 0 Duty Cycle	None	0
8	PWM 1 Duty Cycle	None	0
9	PWM 2 Duty Cycle	None	0
10	PWM 3 Duty Cycle	None	0

None
On Change of State
At Specified Interval
At Interval and Change of State

Display: [✓ Decimal] Hexadecimal

Figure 14-17

When each of the registers of the node have been configured, click the **SAVE & EXIT** button to save changes and close the Configure Registers dialog box and return to the Node Configuration dialog.

In addition to changing the trigger, from this dialog, the Value for each register can be changed (providing the register is writable). The numbers can be represented in decimal or in hex. Figure 14.16 is set to display in decimal. As an example, register number 1 (Digital Outputs) will directly control the outputs on the node. By changing the Value, the outputs can be set to be on or off.

The values that may be entered are decimals that represent the binary bits that correspond to each individual output.

Decimal Number Value	128	64	32	16	8	4	2	1	0
Corresponding Real World Output	8	7	6	5	4	3	2	1	All Off

Examples: If Decimal Number Value = 128, then Real World Output 8 is ON.
If Decimal Number Value = 8, then Real World Output 4 is ON.
If Decimal Number Value = 40, then Real World Outputs 4 and 6 are both ON.

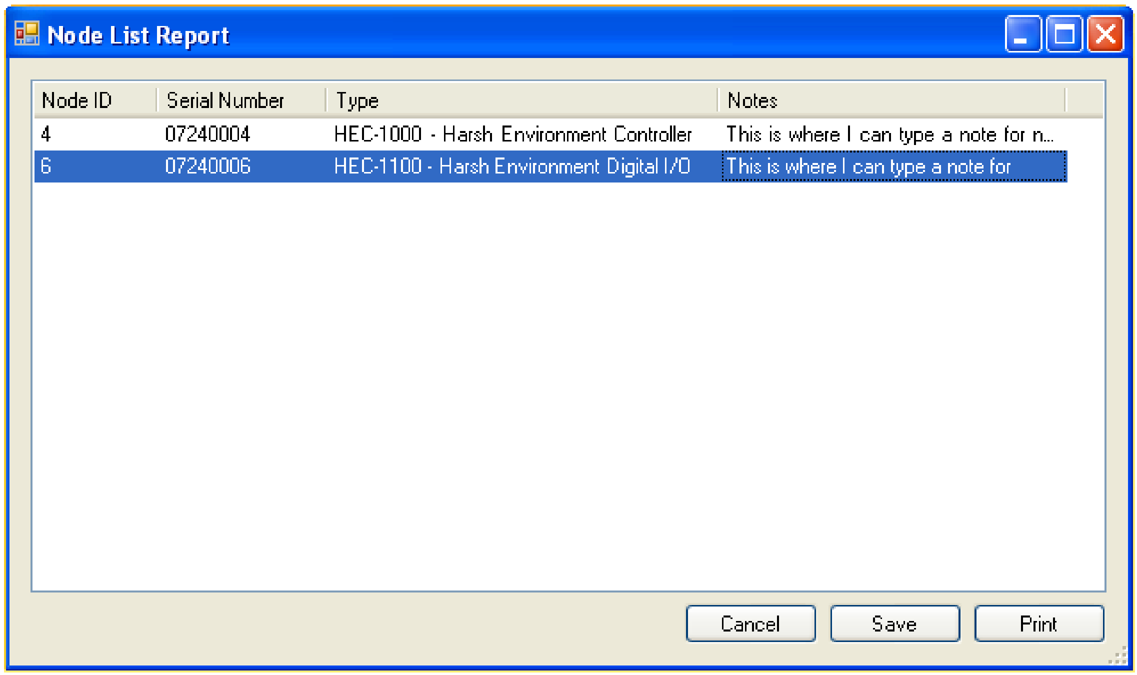
Each non-controller node has unique register assignments. Refer to the actual product manual for details regarding register assignments.

OptiCAN Node List Notes

Notes can be added to the list of nodes to help with documentation and service later. This is accessed from the OptiCAN Configuration Tool. To access this feature, in the Divelbiss OptiCAN Configuration Tool window, use the ***Reports Menu*** and select *Node List*.

The Node List Report window will open. Place the cursor under the Note Heading next to the node of choice. Simply type in the notes for that node. See Figure 14-18.

The node list and notes may be saved and printed for future reference.



Node List Report

Node ID	Serial Number	Type	Notes
4	07240004	HEC-1000 - Harsh Environment Controller	This is where I can type a note for n...
6	07240006	HEC-1100 - Harsh Environment Digital I/O	This is where I can type a note for

Figure 14-18

J1939 Networking / NMEA 2000

J1939 is a standard maintained by the Society of Automotive Engineers (SAE) that defines how information is transferred across a network to allow devices such as engine ECUs to communicate information such as engine speed, engine RPM, etc. to other ECUs or devices. J1939 is essentially a software specification / protocol that operates on a CAN network. NMEA 2000 is based on J1939 with additional special message requirements. As NMEA 2000 is based on J1939, many of the menus and configuration items are generally the same and interchangeable except for noted differences.

J1939 uses CAN 2.0B as its structure. It is typically used on commercial vehicles such as tractor trailers and construction equipment.

This manual section is provides the basics for installing and configuring J1939 support in EZ LADDER Toolkit, using the function blocks and additional features available in EZ LADDER for J1939. It is not intended as a complete J1939 reference document. As such, prior knowledge of J1939 is recommended.

EZ LADDER Toolkit support for J1939 allow for receive and transmitting data on the J1939 bus including items such as PGN request, BAM (global) and CM (specific destination). EZ LADDER also supports J1939 bus address claim.

J1939 PGN Overview

J1939 communication is based on the Parameter Group Number, otherwise known as the PGN. PGNs are defined based on a compilation of information. For example, PGN 61444 is identified as *Electronic Engine Controller 1*. Items transmitted with this PGN designation would be engine speed, driver's demand torque, etc. PGNs are typically transmitted by ECUs (and other devices) at a set rate. By reading appropriate PGNs, controllers and targets can use the data as setpoints and values in the ladder diagram program. Additionally, EZ LADDER Toolkit programs can transmit data using J1939 (P-Series targets only).

Most PGNs are eight bytes in length, but can be a different length. If data isn't available (typically if the PGN is not supported), the data will return a 0xFF. If a 0xFE is returned, this signifies an error.

J1939 SPN Overview

When PGNs are received, they typically include multiple data points (transmitted as part of the PGN). For example, PGN 61444 would be *Electronic Engine controller 1*. When PGN 61444 is received, it contains multiple data points and these points are stored in the data based on byte number. In EZ LADDER Toolkit, these parameters are accessed by their Suspect Parameter Numbers (SPNs).

Installing J1939 in EZ LADDER Toolkit

The information contained in this manual regarding J1939 is specifically for the P-Series PLC on a Chip based targets only. For M-Series based targets, refer to the **M-Series EZ LADDER Toolkit Manual**.

When installing the J1939 support in the project, many configuration settings and parameters (including optional items) must be completed. It is recommended that you have a complete picture of how you want to implement J1939 and use it.

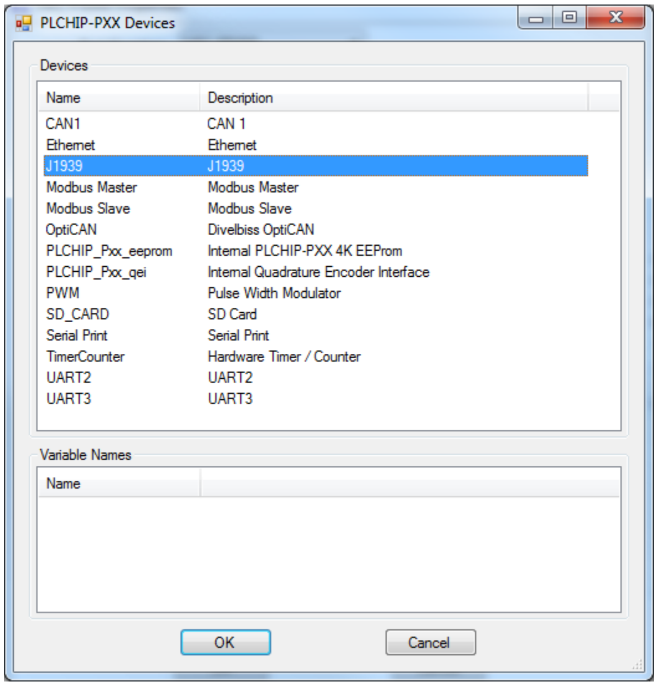
J1939 is installed on a per project (program) basis. Once the J1939 settings are configured, they are stored in the actual ladder diagram project. Actual menus steps to reach the J1939 configuration may vary based on the actual controller used, but the configuration itself is always the same. Divelbiss standard controllers based on P-Series PLC on a Chip (HEC-P5000, VB-2000, etc) are configured based on the part number. For details on specific targets, please see **Chapter 23 - Hardware Targets**.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If J1939 were installed, it would be listed in the *Devices pane* under the Device section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open.

A CAN port must be installed prior to installing J1939/NMEA 2000. See **Installing CAN Network Ports** earlier in this chapter.

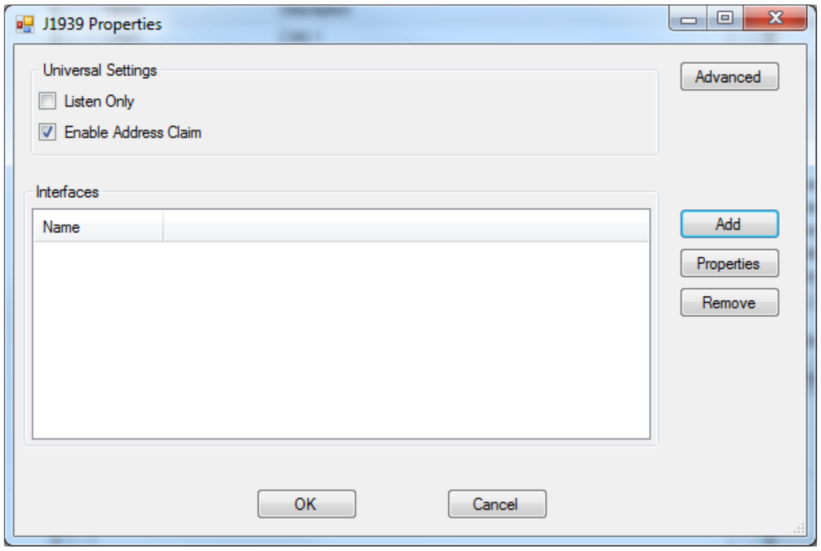
All the available devices and features for the target are shown in the Devices section. Scroll down and find the J1939. Figure 14-19 shows the Target's Devices window.



Name	Description
CAN1	CAN 1
Ethernet	Ethernet
J1939	J1939
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
TimerCounter	Hardware Timer / Counter
UART2	UART2
UART3	UART3

Figure 14-19

Select the **J1939** and click **OK**. The *J1939 Properties* dialog will open. This dialog is used to specify which CAN port is to be used as well as the J1939 Universal Settings. The configuation here will decide how J1939 is implemented. Refer to Figure 14-20.



Chosen settings: Listen Only [ ], Enable Address Claim [✓]

Figure 14-20

Listen Only checkbox
When this box is checked, J1939 is configured to receive J1939. The controller with this EZ LADDER program will receive data, but cannot transmit on the J1939 bus.

Enable Address Claim checkbox
When this box is checked, J1939 is configured to receive and transmit J1939 broadcast data. The controller with this EZ LADDER program will attempt to claim an address on the J1939 bus. With the address claimed, it not only receives data, but can transmit on the J1939 bus.

You should select between Listen Only mode and Enable Address Claim mode. No check boxes are required to receive J1939, but per the J1939 specification, to transmit the unit must claim an address on the network.

If you are only needing to receive J1939 broadcast data (no transmit), it is recommended you select **Listen Only**.

The **ADVANCED** button accesses advanced configuration features such as receive and transmit buffer sizes, PGN and BAM connections. Changing these parameters would be required if larger numbers of simultaneous PGNs or lager buffers were required. This information will be discussed in detail later.

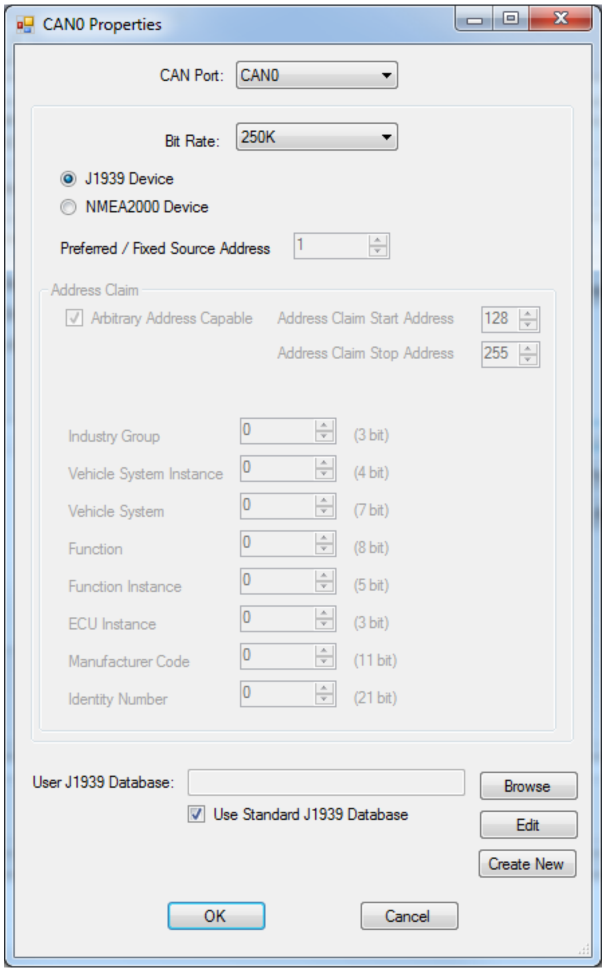
Once the Universal Setting (Listen Only or Enable Address Claim) has been configured, click the **ADD** button. The J1939 Properties dialog will open. Refer to Figure 14-21.

Using the provided *CAN Port* drop down box, select the CAN port to use for the J1939 communication. This should be the CAN port connected to the J1939 network.

With the CAN port selected, other items then become available to configure. The available configuration items is dependent upon the mode selected previously (listen or claim address). Figure 14-21 illustrates the dialogs configured each way.

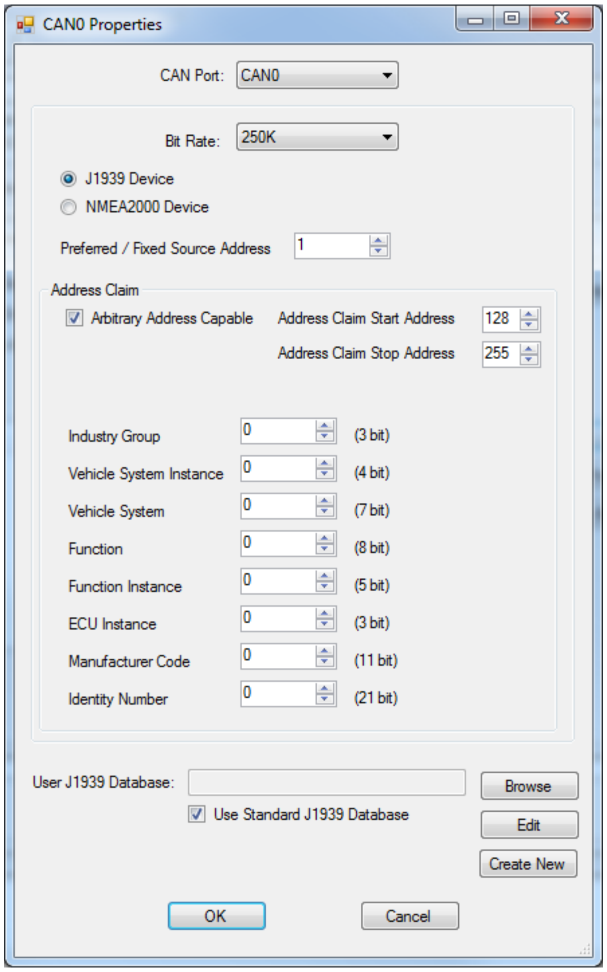
In listen mode, the amount of configuration items is reduced significantly. Configure the items as required for the specific application requirements for interfacing to J1939.

Listen Only Mode



CAN Port: CAN0
Bit Rate: 250K
[✓ J1939 Device] NMEA2000 Device
Preferred / Fixed Source Address: 1
Address Claim
[✓] Arbitrary Address Capable
Address Claim Start Address: 128
Address Claim Stop Address: 255
Industry Group: 0 (3 bit)
Vehicle System Instance: 0 (4 bit)
Vehicle System: 0 (7 bit)
Function: 0 (8 bit)
Function Instance: 0 (5 bit)
ECU Instance: 0 (3 bit)
Manufacturer Code: 0 (11 bit)
Identity Number: 0 (21 bit)
User J1939 Database:
[✓] Use Standard J1939 Database

Claim Address Mode



CAN Port: CAN0
Bit Rate: 250K
[✓ J1939 Device] NMEA2000 Device
Preferred / Fixed Source Address: 1
Address Claim
[✓] Arbitrary Address Capable
Address Claim Start Address: 128
Address Claim Stop Address: 255
Industry Group: 0 (3 bit)
Vehicle System Instance: 0 (4 bit)
Vehicle System: 0 (7 bit)
Function: 0 (8 bit)
Function Instance: 0 (5 bit)
ECU Instance: 0 (3 bit)
Manufacturer Code: 0 (11 bit)
Identity Number: 0 (21 bit)
User J1939 Database:
[✓] Use Standard J1939 Database

Figure 14-21

Configuration Items

The items that are to be configured must be configured specifically for your application requirements for proper operation.

Bit Rate:	Drop down box. Select 250K or 500K. Standard bus uses 250K.
J1939 Device/NMEA 2000 Device:	Select between J1939 and NMEA 2000 network. Choose the appropriate network.
Preferred/Fixed Source Address:	Number from 1 to 100. This is the first address that the controller will try and use on the J1939 network. This box works with the Arbitrary Address Capable box and addresses. If the Arbitrary Address Capable box is checked, then the Preferred/ Fixed Address is tried first. If the address is not available on the network, then the controller will aribtrarily try additional addresses based on the limits set. If the Aribitrary Address Capable box is not checked, then only this one address will be attemped, even if it is not available. This box is not available in listen mode.

Arbitrary Address Capable:	If this box is checked, then the Preferred/Fixed Address is tried first. If the address is not available on the network, then the controller will aribtrarily try additional addresses based on the Address Claim Start/Stop addresses set.This box is not available in listen mode.
Address Claim Start Address:	If arbitrary addressing is required, this is the first arbitrary address that will be tried.
Address Claim Stop Address:	If arbitrary addressing is required, this is the last arbitrary address that will be tried.
Industry Group, Vehicle System Instance, Function, Function Function Instance, ECU Instance, Manufacturer Code, Identity Number	These items are specific items that may be used on the J1939 bus for communication and aribitration. These items are optional and would be provided by the actual J1939 bus or equipement manufacturer. Note: if NMEA 2000 is selected instead of J1939 above, then some of these names will change as required by NMEA 2000.
User J1939 Database:	This location box and check box for Use Standard J1939 Database identifies the J1939 database of PGNs and SPNs to be used on this project. The Use Standard J1939 Database checkbox forces the use of the EZ LADDER Toolkit standard PGN and SPN database.

EZ LADDER Toolkit supports the ability to add new PGNs and SPNs that are not currenlty in the standard database as needed. This topic will be covered in a later section.

With all the items configured, click the OK button to close dialog and save the settings. Click OK to close and save the J1939 properties dialog.

Up to two J1939 networks may be accessed (one for each CAN port, up to 2 maximum) by repeating the same steps for the addtional J1939 network with a different CAN port.

click the OK button to close the target's properties. Click OK to close and save the Project Settings. The J1939 is now installed and configured and is ready to be used in the ladder diagram program.

Standard J1939 Database

Included as part of EZ LADDER Toolkit is the Divelbiss Standard J1939 database. This database has been preloaded with common J1939 PGNs (and SPNs). During the configuration previously shown, the database that is used for the storing J1939 PGNs is identified. The Standard J1939 database cannot be modified (added to or deleted from). If additional PGNs are required that are not included in the Standard J1939 database, then the User J1939 database must be identifed and used during the configuration. To use the Standard J1939 database, ensure the check box *Use Standard J1939 Database* is checked. If a user J1939 database is to be used, then uncheck the box.

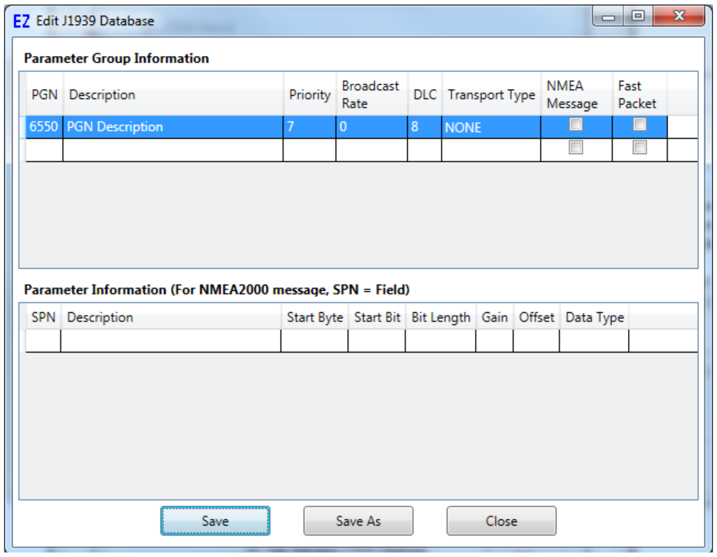
User J1939 Database

If the Standard J1939 database does not include all the PGNs that are required, the option is provided to use a *User J1939 database*. This custom database may be configured and used to store the PGN list for your projects.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If J1939 were installed, it would be listed in the *Devices pane* under the Device section. Select the J1939 (under Network) and click the **PROPERTIES** button. The J1939 Properties dialog will open. Select the CAN port for the J1939 and click the **PROPERTIES** button. The CAN port Properties window will open.

A built-in editor is included in EZ LADDER Toolkit for creating and editing user J1939 databases. Refer to Figure 14-21. To create a new user J1939 database, click the **CREATE NEW** button. The Edit J1939 database window will open. Refer to Figure 14-22.



Parameter Group Information

PGN	Description	Priority	Broadcast Rate	DLC	Transport Type	NMEA Message	Fast Packet
6550	PGN Description	7	0	8	NONE	☐	☐
						☐	☐

Parameter Information (For NMEA2000 message, SPN = Field)

SPN	Description	Start Byte	Start Bit	Bit Length	Gain	Offset	Data Type

Figure 14-22

Click into the fields provided and add the PGN (PGN number), PGN Description, Priority Broadcast Rate DLS, and Transport Type for each PGN. If this for NMEA 2000, click the NMEA Message chechbox and if it is a Fast Packet for NMEA 2000, click the Fast Packet checkbox.

For each PGN added in the top pane, SPNs may be added in the bottom pane. With the PGN selected in the top PGN pane (Parameter Grou Information), add SPNs in the SPN pane at the bottom (Parameter Information). The data for the PGN/SPN is provided by the manufacturer of the device or the J1939/NMEA 2000 specification. Enter the data for SPN, Description, Start Byte, Start Bit, Bit Length, Gain, Offset and Data Type. For NMEA 2000, the SPN is the Field.

Use the **SAVE** and **SAVEAS** buttons to set the filename of the user J1939 database and save (update) as new PGNs are added. The **CLOSE** button is used to close the editor.

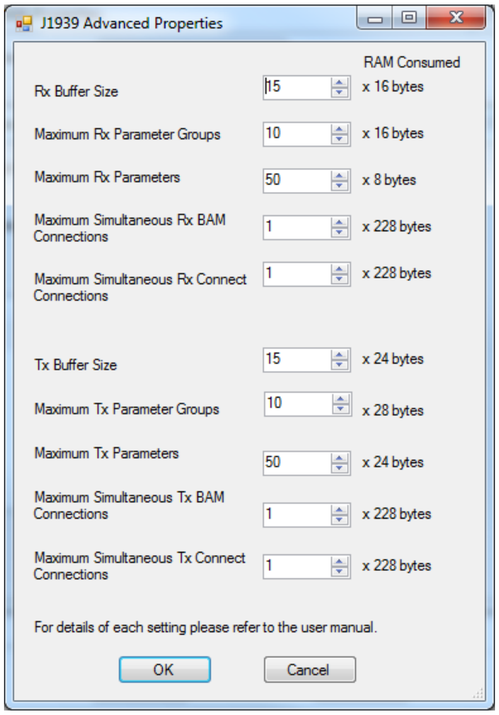
Since the J1939 database cannot be edited, if you require PGNs from the Standard J1939 database and addtional not in the database, you will need to add **ALL** the PGNs that you require to the User J1939 database.

Refer to Figure 14-21. To select your User J1939 database, uncheck the Use Standard J1939 Database and click the **BROWSE** button. Browse to the location your J1939 database is located and click **OPEN**. The location of your User J1939 database should now be locate in the box. Ensure all the J1939 settings are correct and click **OK** with the User J1939 Database selected to close the CAN port Properties window. Exit out of all the remaining project settings windows. Be sure to save your ladder diagram project.

Advanced J1939 Configuration

EZ LADDER Toolkit provides advanced configuration options for J1939. These configuration items may be adjusted if the default configuration is not sufficient for the application.

With the J1939 Properties window open (See Figure 14-20), click the **ADVANCED** button. The J1939 Advanced Properties window will open. The currently shown settings are the default transmit and receive configuration items (assuming that no advanced changes were made previously). See Figure 14-23.



		RAM Consumed
Rx Buffer Size	15	x 16 bytes
Maximum Rx Parameter Groups	10	x 16 bytes
Maximum Rx Parameters	50	x 8 bytes
Maximum Simultaneous Rx BAM Connections	1	x 228 bytes
Maximum Simultaneous Rx Connect Connections	1	x 228 bytes
Tx Buffer Size	15	x 24 bytes
Maximum Tx Parameter Groups	10	x 28 bytes
Maximum Tx Parameters	50	x 24 bytes
Maximum Simultaneous Tx BAM Connections	1	x 228 bytes
Maximum Simultaneous Tx Connect Connections	1	x 228 bytes

For details of each setting please refer to the user manual.

Figure 14-23

From inside this window, items such as transmit and receive buffer size, number of PGNs, etc. may be adjusted.

These advanced parameters should only be adjusted if necessary for the application. Adjusting these numbers affects the amount of RAM used and available for the entire ladder diagram project during Compilation. Cautionmust be taken to not use excessive RAM for J1939 unnecessarily as it is possible to run out of RAM memory.

Receiving Data with J1939

With the J1939 network configured in the Project Settings of EZ LADDER Toolkit, data may be received in the ladder diagram. To receive data using J1939 (NMEA 2000), the J1939_RX_PGN Function block is used. This function block is automatically added to the functions drop down list when J1939/NMEA 2000 is installed in the project settings.

To receive data, use the Functions drop down box on the toolbar and select **J1939_RX_PGN**. Click the INSERT FUNCTION button and then click in the ladder diagram workspace where you want to insert the J1939_RX_PGN function block.

The J1939 RX Properties dialog box will open. This box is used to configure this specific instance of the J1939_RX_PGN function used in the program. Refer to Figure 14-24.

The J1939 RX Properties must be configured for each insert of a J1939_RX_PGN function block as each insert is a unique instance of the function block.

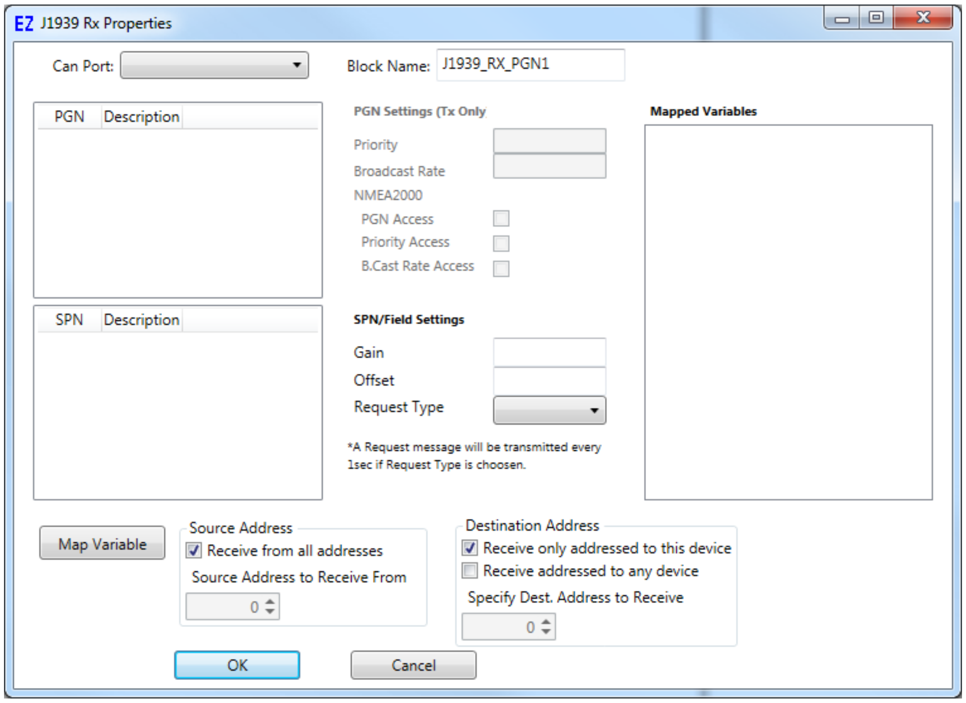


Figure 14-24

Using the drop down menu, select the CAN port for the J1939/NMEA 2000 network. Along the left side of the dialog, below the CAN port drop down, is a pane with a list of PGNs (PGNs in the configured database). By selecting a PGN, the SPN pane below populates with the supported SPNs for the highlighted PGN. As different PGNs are selected (highlighted) in the PGN pane, the PGN settings to the right change as do the SPN pane.

Select the PGN to receive data from. The SPN pane will update. Select the desired SPN in the SPN pane. The SPN/Field setting will update with information based on the J1939/User database.

The Gain, Offset and Request Type are stored in the database but may be overridden for this instance (of the J1939_RX_PGN) function block.

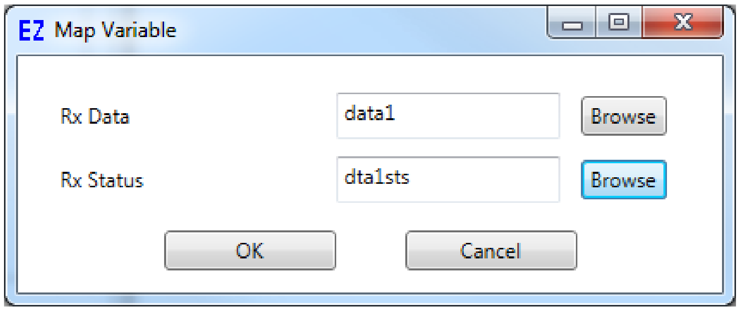
The Source Address area determines what J1939 address are may be received from for the selected PGN. If the ***Receive from all addresses*** is checked, then any device on the network that broadcasts this PGN will be received from. If only specific a specific J1939 network address should be received from, uncheck the ***Receive from all addresses*** checkbox and use the ***Source Address to Receive From*** box to set the J1939 network address.

The source of the J1939 broadcasts received may be configured as Receive from all addresses or may be limted to a specific address based on the Source Address area settings.

In addition to controlling which Source Addresses are received, the receive function block may be configured based on a Destination address in the Destination Address section. Using these settings, the function block will receive all global broadcasts of a PGN (Receive addressed to any device), broadcasts to this specific controller or device (Receive only addressed to this device) or it may listen in on a broadcast to a specific address broadcast (Specifiy Dest. Address to Receive). These configuration items are set by check boxes and an Address box in the Destination Address area.

The function block instance may be configured to receive all global broadcasts to this PGN, only broadcasts to this specific address or to any specific address based on the settings in the Destination Address area.

The next step is to identify where the SPN data that is received will be stored. All J1939 data is stored in variables. To set the variable(s) used, click the **MAP VARIABLE** button. The Map Variable dialog will open. Using the **BROWSE** buttons, select the variable to store the received data to (Rx Data) and optionally, select the variable to store the received data status (ie valid, not seen, etc). Click **OK** when the variables have been set. Refer to Figure 14-25.



Rx Data: data1

Rx Status: dta1sts

Figure 14-25

Repeat these steps for any SPN of the selected PGN you want to receive data from in this instance of the J1939_RX_PGN function block. Figure 14-26 shows two SPNs selected and mapped to variables for PGN 61442.

Multiple SPNs may be mapped to a variables in one J1939_RX_PGN function block instance providing that all the SPNs are part of the same PGN (selected PGN).

Click **OK** when all the SPNs required have been mapped to variables. The function block is now placed in the ladder diagram.

The EN (enable) should be tied to the left power rail or using a contact to control when the specific J1939_RX_PGN function block is enabled and receives data. The Q output goes true when the data is received for one ladder diagram scan and then goes false on the next ladder diagram scan.

The ER is the error output. It must be connected to an integer variable. This variable will store the status of the last receive (0= Valid Data or No Error, -1 = PGN Not Seen, -2 = PGN Failed Update or No data received in last 5 seconds).

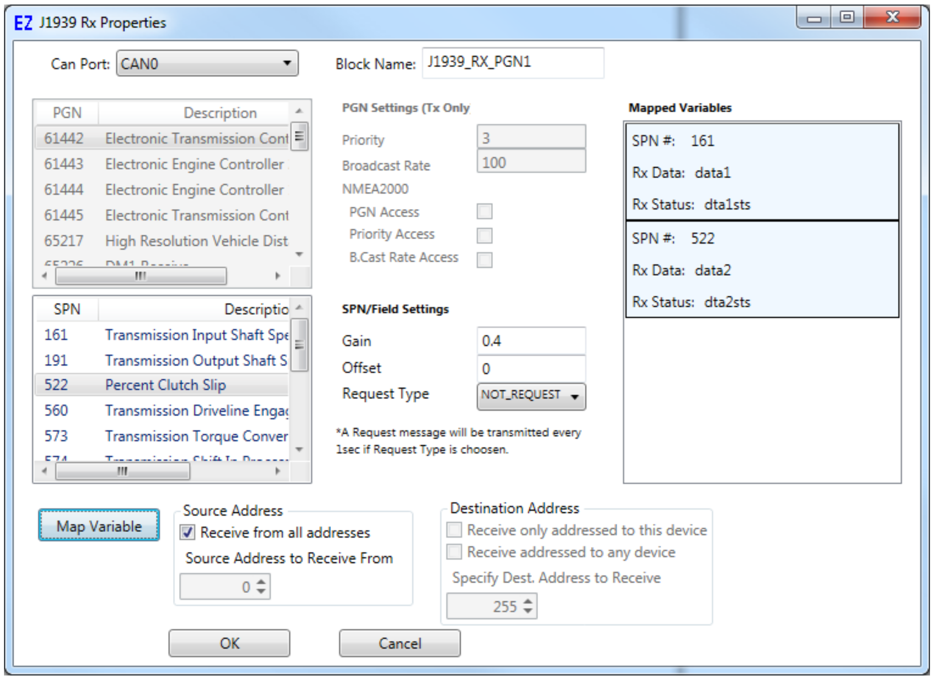

J1939 Rx Properties
Can Port: CAN0
Block Name: J1939_RX_PGN1
PGN Description
61442 Electronic Transmission Cont
61443 Electronic Engine Controller
61444 Electronic Engine Controller
61445 Electronic Transmission Cont
65217 High Resolution Vehicle Dist
SPN Descriptio
161 Transmission Input Shaft Spe
191 Transmission Output Shaft S
522 Percent Clutch Slip
560 Transmission Driveline Engag
573 Transmission Torque Conver
PGN Settings (Tx Only
Priority 3
Broadcast Rate 100
NMEA2000
PGN Access
Priority Access
B.Cast Rate Access
SPN/Field Settings
Gain 0.4
Offset 0
Request Type NOT_REQUEST
*A Request message will be transmitted every 1sec if Request Type is choosen.
Mapped Variables
SPN #: 161
Rx Data: data1
Rx Status: dta1sts
SPN #: 522
Rx Data: data2
Rx Status: dta2sts
Map Variable
Source Address
Receive from all addresses
Source Address to Receive From
0
Destination Address
Receive only addressed to this device
Receive addressed to any device
Specify Dest. Address to Receive
255
OK
Cancel

Figure 14-26

The SA is the Source Address output. It must be connected to an integer variable. This variable will store the Source Address of the last receive (which address this PGN was received from).

The DA is the Destination Address output. It must be connected to an integer variable. This variable will store the Destination Address of the last receive if the PGN had a specific destination in the broadcast packet. If the broadcast was a global broadcast, then the DA does not apply.

Figure 14-27 illustrates a complete J1939_RX_PGN function block inserted in a ladder diagram program.

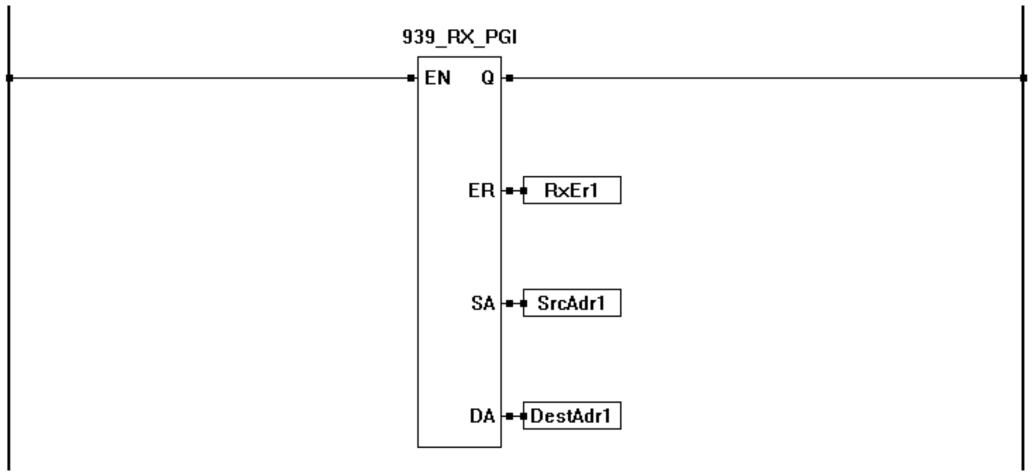


Figure 14-27

SPN Status Mapped Variables

The mapped status (not data) variables for the SPNs of the function block have their own error and status reporting. The SPN error status reporting is only valid if the SPN is set as STANDARD or STATE in the J1939 Database). The SPN status is 0 = Valid, -1 = Not Seen, -2 = Data Error, -3 = Not Supported -4 = Data Reserved.

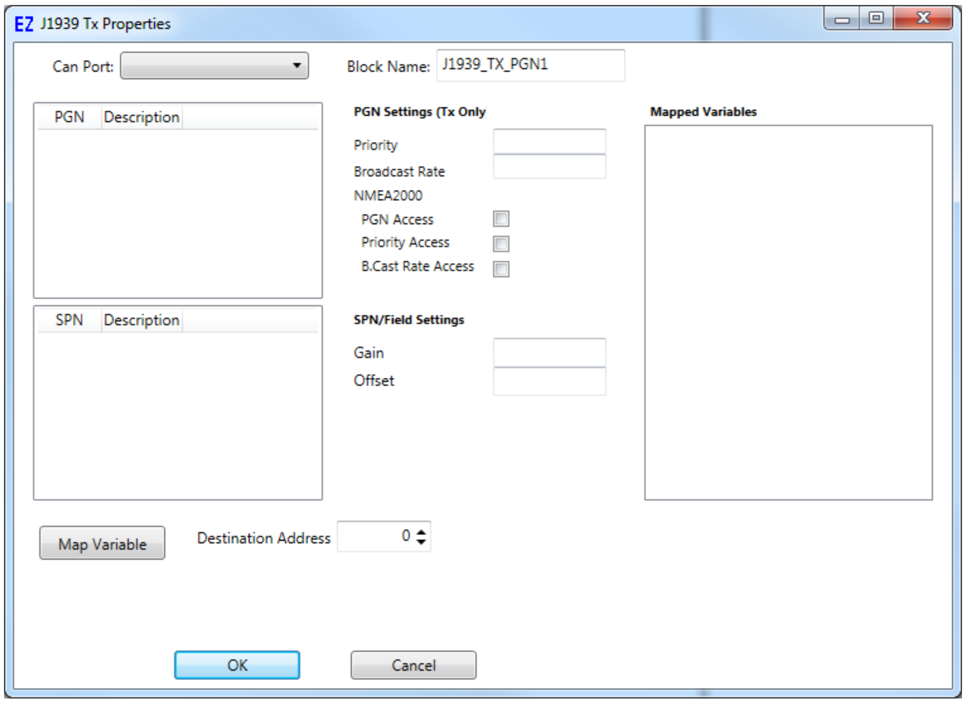
Transmitting Data with J1939

With the J1939 network configured in the Project Settings of EZ LADDER Toolkit, data may be transmitted using the ladder diagram. To transmit data using J1939 (NMEA 2000), the J1939_TX_PGN Function block is used. This function block is automatically added to the functions drop down list when J1939/NMEA 2000 is installed in the project settings.

To transmit data, use the Functions drop down box on the toolbar and select **J1939_TX_PGN**. Click the **INSERT FUNCTION** button and then click in the ladder diagram workspace where you want to insert the J1939_TX_PGN function block.

The J1939 TX Properties dialog box will open. This box is used to configure this specific instance of the J1939_TX_PGN function used in the program. Refer to Figure 14-28.

The J1939 RX Properties must be configured for each insert of a J1939_RX_PGN function block as each insert is a unique instance of the function block.



Block Name: J1939_TX_PGN1

Destination Address: 0

Figure 14-28

Using the drop down menu, select the CAN port for the J1939/NMEA 2000 network. Along the left side of the dialog, below the CAN port drop down, is a pane with a list of PGNs (PGNs in the configured database). By selecting a PGN, the SPN pane below populates with the supported SPNs for the highlighted PGN. As different PGNs are selected (highlighted) in the PGN pane, the PGN settings to the right change as do the SPN pane.

Select the PGN to transmit data as. The SPN pane will update. Select the desired SPN in the SPN pane. The SPN/Field setting will update with information based on the J1939/User database.

The Destination Address area determines the type of J1939 broadcast. If set to 255, then the broadcast is global and will not have a specific destination address. If the Destination Address is set to a specific number, then the broadcast is sent with a that specific destination address.

Destination address may not be settable to a specific address. Specific address or global is also dependent upon the PGN/SPN selected and the database settings.

The PGN Settings are based on the settings from the J1939/User database. These values may be adjusted for this instance of the function block. The adjustable values include the Priority and Broadcast Rate. Additionally, checkboxes are provided for NMEA 2000 optional settings (PGN Access, Priority Access and B.Cast Rate Access). Refer to the NMEA 2000 specification for details on these configuration items.

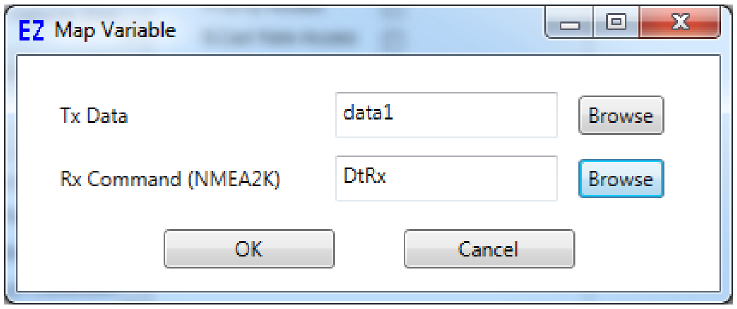
The Priority and Broadcast Rate for th PGN are stored in the database but may be overridden for this instance (of the J1939_TX_PGN) function block.

The SPN Settings are based on the settings from the J1939/User database. These values may be adjusted for this instance of the function block. The adjustable values include the Gain and Offset.

The Gain and Offset for the SPN are stored in the database but may be overridden for this instance (of the J1939_TX_PGN) function block.

The next step is to identify where the SPN data that will be broadcast will be gathered from. All J1939 broadcast data must be mapped from variables. To set the variable(s) used, click the **MAP VARIABLE** button. The Map Variable dialog will open. Using the **BROWSE** buttons, select the variable to gather the transmit data from (Tx Data). For NMEA 2000 Commanded Data, select the variable for the Rx Command (NMEA2K). Click **OK** when the variables have been set. Refer to Figure 14-29. Refer to the NMEA 2000 specification regarding Commanded Data.

Double-clicking the SPN will open the Map Variable dialog.



Tx Data: data1
Rx Command (NMEA2K): DtRx

Figure 14-29

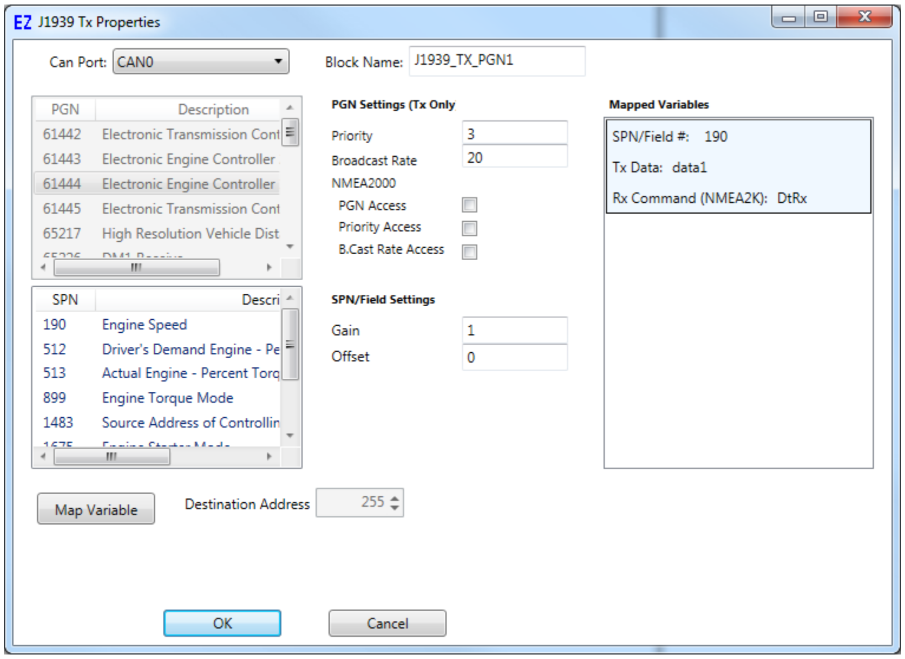
Repeat these steps for any SPN of the selected PGN you want to transmit data as in this instance of the J1939_TX_PGN function block. Figure 14-30 shows one SPN selected and mapped to variables for PGN 61442.

Multiple SPNs may be mapped to a variables in one J1939_TX_PGN function block instance providing that all the SPNs are part of the same PGN (selected PGN).

Click OK when all the SPNs required have been mapped to variables. The function block is now placed in the ladder diagram.

The EN (enable) should be tied to the left power rail or using a contact to control when the specific J1939_TX_PGN function block is enabled and transmits data. The Q output is true when the function block is enabled.

When the Enable input is true, the function block is active and the PGN/SPNs will broadcast based on the rates set in the database or the overridden values when the function block was placed. If the Enable is false, the function block is disabled and the PGN/SPNs will not transmit (broadcast).



Can Port: CAN0

Block Name: J1939_TX_PGN1

PGN	Description
61442	Electronic Transmission Cont
61443	Electronic Engine Controller
61444	Electronic Engine Controller
61445	Electronic Transmission Cont
65217	High Resolution Vehicle Dist

SPN	Descri
190	Engine Speed
512	Driver's Demand Engine - Pe
513	Actual Engine - Percent Torq
899	Engine Torque Mode
1483	Source Address of Controllin

PGN Settings (Tx Only

Priority: 3
Broadcast Rate: 20
NMEA2000
PGN Access ☐
Priority Access ☐
B.Cast Rate Access ☐

SPN/Field Settings

Gain: 1
Offset: 0

Mapped Variables

SPN/Field #: 190
Tx Data: data1
Rx Command (NMEA2K): DtRx

Destination Address: 255

Figure 14-30

Figure Figure 14-31 illustrates a complete J1939_TX_PGN function block inserted in a ladder diagram program.

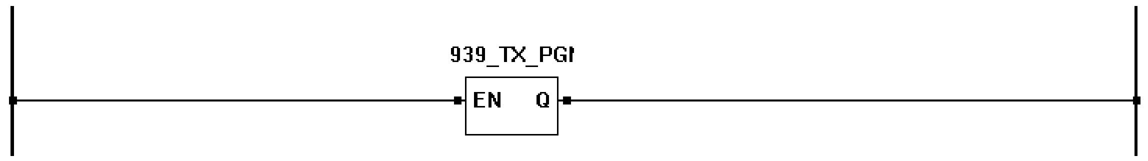


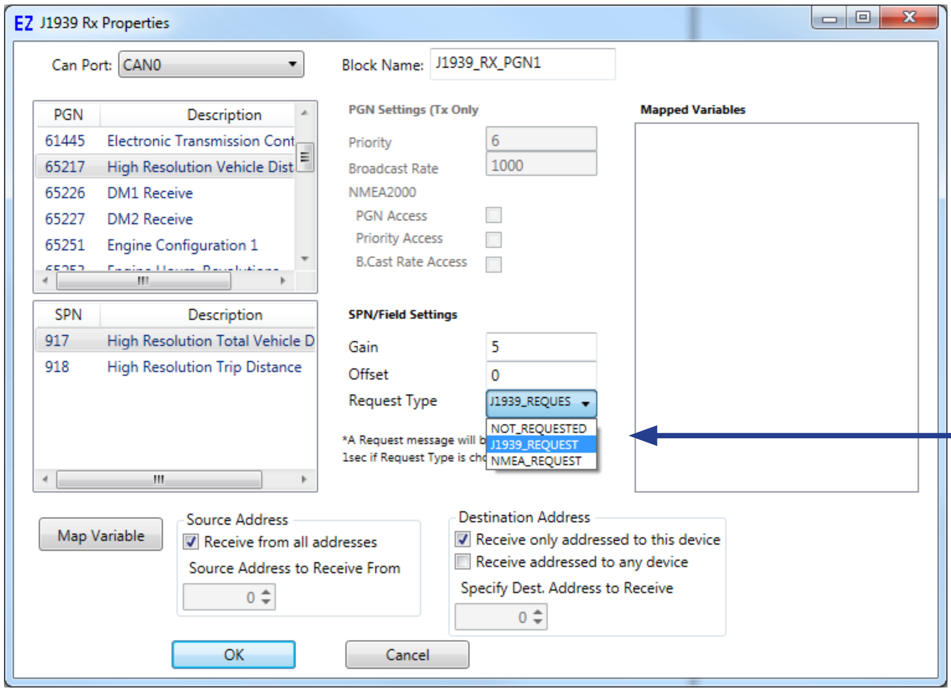
Figure 14-31

PGN Request

J1939/NMEA 2000 PGN request is supported in EZ LADDER Toolkit. If a specific PGN is required and it is not broadcast on a schedule or if the PGN data is required more often than the device is broadcasting it (if the broadcast rate of the PGN is 10 seconds, but you need the data every 4 seconds), the PGN Request may be used. The PGN Request is exactly as it's name implies, it re quests the device to broadcast the PGN.

This feature is accessed in the J1939_RX_PGN function block. With a PGN and SPN selected, a drop-down box is available in the SPN/Field Settings area of the Properties window. Refer to Figure 14-32. Mapped variables to receive the data also required.

When the Request Type is set to J1939_REQUEST, the controller will request the device broadcast the PGN. The request is sent every 1 second. The NMEA_Request is the NMEA 2000 version of the PGN request.


EZ J1939 Rx Properties

Can Port: CAN0
Block Name: J1939_RX_PGN1

PGN	Description
61445	Electronic Transmission Cont
65217	High Resolution Vehicle Dist
65226	DM1 Receive
65227	DM2 Receive
65251	Engine Configuration 1

SPN	Description
917	High Resolution Total Vehicle D
918	High Resolution Trip Distance

PGN Settings (Tx Only
Priority: 6
Broadcast Rate: 1000
NMEA2000
PGN Access ☐
Priority Access ☐
B.Cast Rate Access ☐

SPN/Field Settings
Gain: 5
Offset: 0
Request Type: J1939_REQUES
NOT_REQUESTED
J1939_REQUEST
NMEA_REQUEST
*A Request message will b
1sec if Request Type is cha

Mapped Variables

Source Address
☑ Receive from all addresses
Source Address to Receive From: 0

Destination Address
☑ Receive only addressed to this device
☐ Receive addressed to any device
Specify Dest. Address to Receive: 0

Drop Down Box. Select from NOT_REQUEST-ED, J1939_REQUEST and NMEA_REQUEST

Figure 14-32

BAM

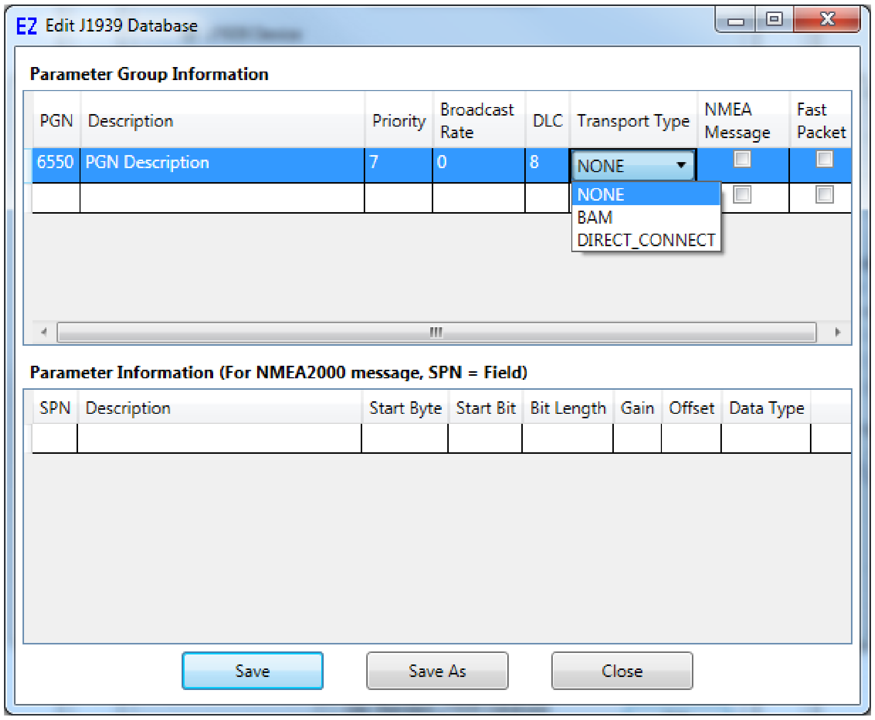
In the event that data needs to be transmitted that is larger than the standard 16 bytes for the normal J1939 PGN/SPN communication, J1939 also provides the BAM message. EZ LADDER Toolkit support the BAM message. Generally, the BAM message will take larger amounts of data that need trasmitted an break it into smaller sizes. The J1939 BAM message will transmit the information regarding the message size and number of packets that are required and then transmit the packets of data. The data is transmitted with a 50 millisecond transmit time then waits 50 milliseconds to send the next packet. This repeats until all the data of the BAM message has been transmitted. The BAM message is a global transmit.

The message Transport Type is defined in the database and it determines the type of message (None, BAM or DIRECT_CONNECT). To set a PGN as a BAM message, it must be configured in the J1939/User database. Figure 14-33 illustrates the configuration options drop-down boxes.

The controller will handle all the data manipulation required to transmit BAM messages if configured to use BAM in the database.

DIRECT CONNECT

J1939 Direct Connect is supported in EZ LADDER Toolkit and can be selected as the Transport Type for a PGN in the J1939/User database. No additional configuration is required. Refer to the J1939 specification for more information regarding Direct Connect.


EZ Edit J1939 Database
Parameter Group Information
NONE
BAM
DIRECT_CONNECT
Parameter Information (For NMEA2000 message, SPN = Field)
Save
Save As
Close

PGN	Description	Priority	Broadcast Rate	DLC	Transport Type	NMEA Message	Fast Packet
6550	PGN Description	7	0	8	NONE	☐	☐

SPN	Description	Start Byte	Start Bit	Bit Length	Gain	Offset	Data Type

Figure 14-33

CHAPTER 15

SPI Devices and Support

This chapter provides basic information to understand how to install, configure and use the SPI Devices and SPI features in the EZ LADDER Toolkit.

Chapter Contents

SPI Bus Devices

EZ LADDER Toolkit provides built-in support for the use of several SPI devices. These supported devices are easily integrated with PLC on a Chip™ and used via EZ LADDER Toolkit variables and function blocks. Generally, these devices are installed and configured using the Project Settings and are not supported on all targets. These devices may be factory implemented on other hardware targets.

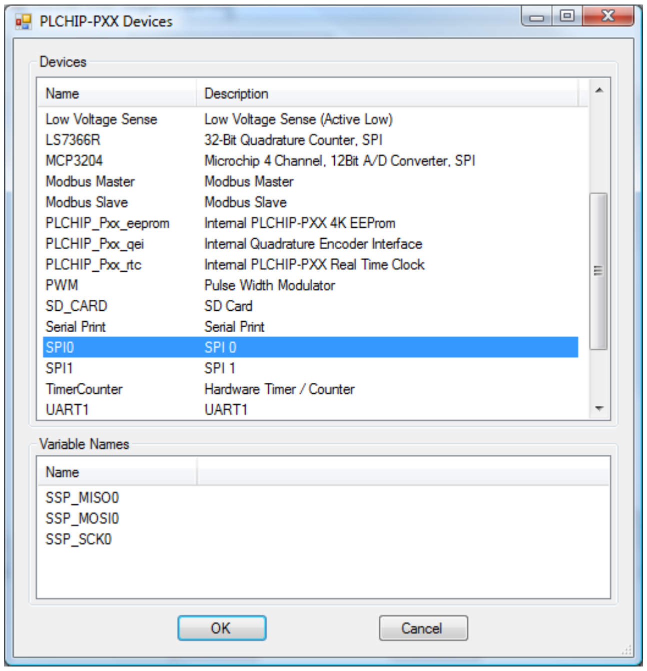
Installing an SPI Bus

Before any of the above listed / supported SPI devices may be installed in EZ LADDER Toolkit, an SPI bus must be installed.

! SPI Port availability is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if SPI Ports are supported. SPI devices must be connected to the P-Series PLC on a Chip™ per design guidelines for proper operation.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If any SPI port were installed, it would be listed in the *Devices pane* under the Bus\SPI section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the SPI ports (SPI0, SPI1, etc). Figure 15-1 shows the Target's Devices window.



Name	Description
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0
SPI1	SPI 1
TimerCounter	Hardware Timer / Counter
UART1	UART1

Variable Names

Name
SSP_MISO0
SSP_MOSI0
SSP_SCK0

Figure 15-1

Select **SPIx** and click OK. The *SPI Properties* dialog will open. See Figure 15-2. All SPI Devices require Chip Select pins, but they are typically selected / identified when the actual SPI device is installed. This dialog allows for reserving Chip Select pins specifically when using structured text only.

Each SPI Device requires the use of a Chip Select pin (GPIO) from the P-Series PLC on a ChipTM. As chip select pins are reserved, they should not / cannot be used in a program as digital I/O. Designs must identify all chip select pins while mapping the digital I/O. Each device on an SPI bus required its own individual chip select pin.

While each device requires a single chip select pin. Multiiple devices may be connected to an SPI port provided that SPI device is compatible and supported.

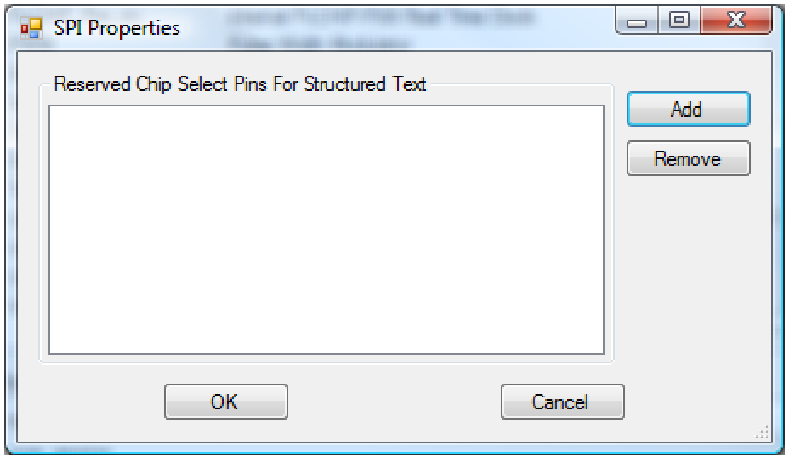
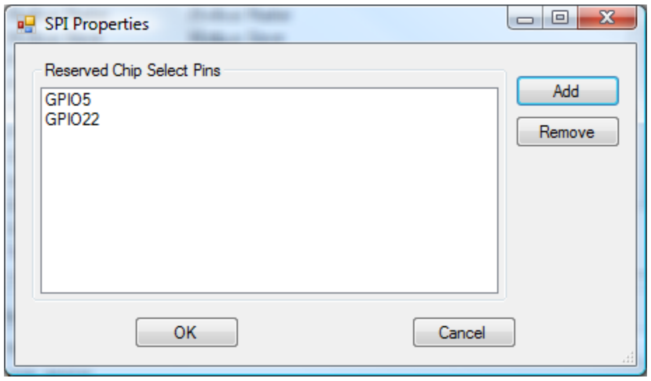


Figure 15-2

If using structured text, Click the ADD button. The SPI CS dialog will open. Using the provided drop-down CS Output menu, select the GPIO to reserve as a chip select pin for the SPI bus for structured text only. Repeat this step until all the required chip selects have been installed and are listed in the Reserved Chip Select Pins pane of th SPI Properties dialog. See Figure 15-3. If not using structured text, click OK to close and exit the SPI Properties dialog and return to the Target Properties window.



GPIO5
GPIO22

Figure 15-3

If using structured text, when all the chip selects have been reserved, click OK. The Target's Devices window will close and the previous target properties window will now list the SPI port as an installed device.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The SPI port is now installed and ready to be used and additional SPI devices may be installed and used in the ladder diagram.

Installing Supported SPI Bus Devices

The following SPI devices are supported by EZ LADDER Toolkit.

LS7366R 32 Bit Quadrature Counter

The LS7366R is a 32 bit Quadrature Counter integrated circuit with an SPI interface. EZ LADDER Toolkit has built-in software support for using this device on an SPI port.

The LS7366R is a hardware device and requires additional circuitry and knowledge to interface it an EZ LADDER supported target. This chapter discusses the basics of using the LS7366R in the ladder diagram and minor references to hardware when needed.

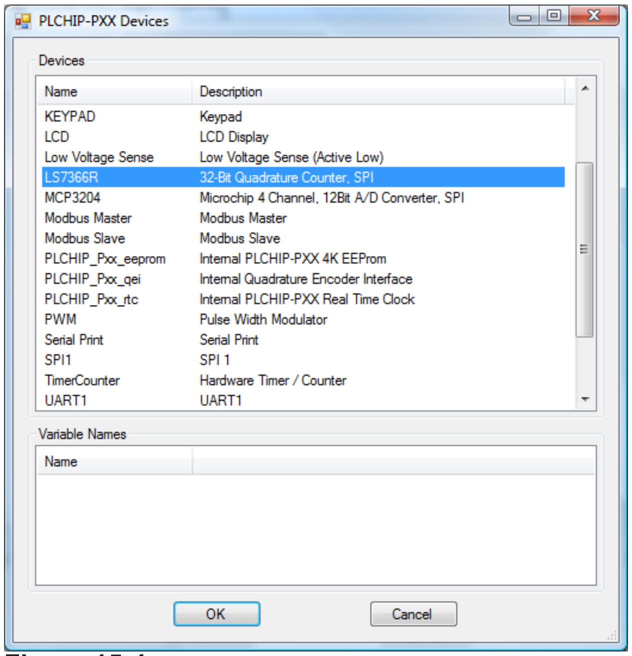
LS7366R / SPI support is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if SPI devices are supported.

Installing the LS7366R in the Ladder Diagram Project

To be able to use the LS7366R in an EZ LADDER Toolkit ladder diagram project, the LS7366R must first be installed and configured. As the PLC on a Chip™ is the most commonly used target for the LS7366R, it will be used as an example to install and configure the LS7366R.

The LS7366R is configured using the Project Settings. Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If a LS7366R device were installed, it would be listed in the *Devices pane* under the Bus\SPI section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the LS7366R. Figure 15-4 shows the Target's Devices window.



Name	Description
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
Serial Print	Serial Print
SPI1	SPI 1
TimerCounter	Hardware Timer / Counter
UART1	UART1

Figure 15-4

Click OK. The LS7366R Properties dialog will open. Ths dialog selects the SPI Port and Chip Select to be used for this LS7366R device. See Figure 15-5.

Multiple LS7366R devices may be added to an SPI port provided that each device has a unique chip select output specified.

The SPI port must be installed previously or no SPI ports will show available in drop down configuration menus.

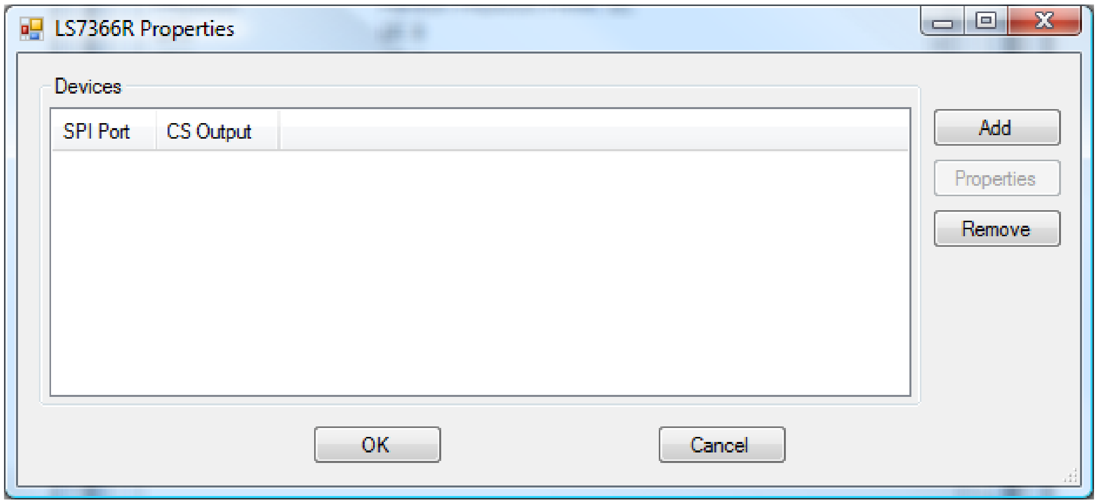


Figure 15-5

Click the ADD button. An additional LS7366R Properties window will open.

Select the SPI port from the drop down menu and select the general purpose output pin (GPO) that will serve as this device's chip select (CS). With these two devices selected, additional channel information will be available to configure. See Figure 15-6. Any chip select pins reserved for structured text will not be visible in the drop-down menu.

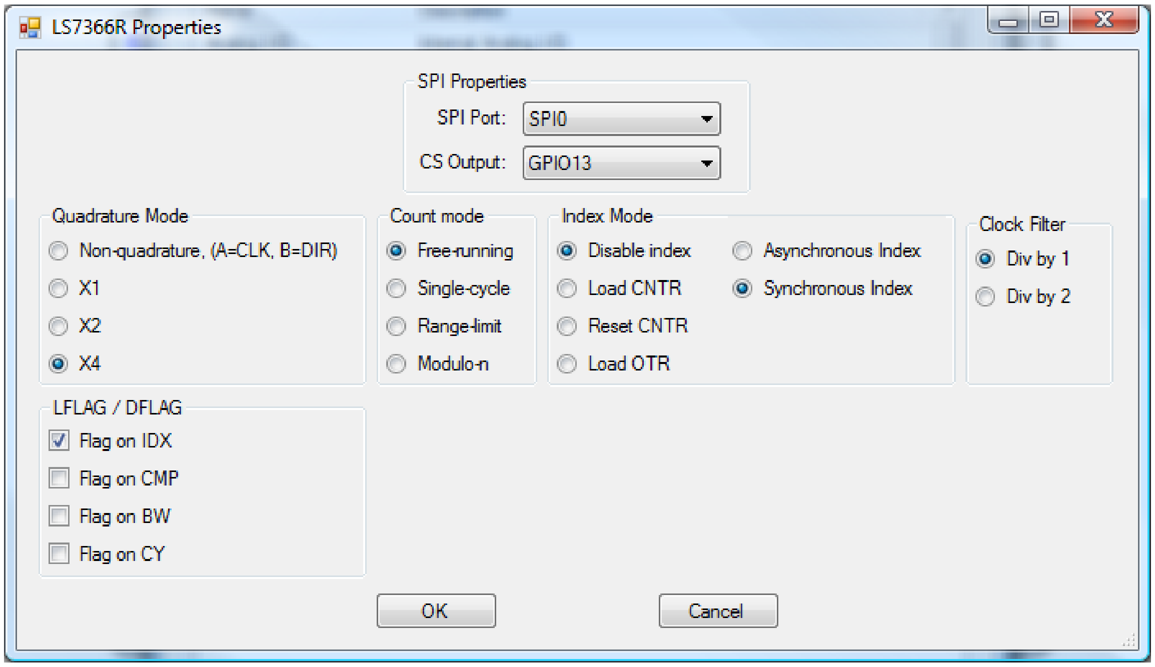
The LS7366R may be configured to run in several modes. Each mode has specific operation parameters and features that may be utilized in the ladder diagram project. These modes and parameters are configured in this dialog box.

Refer to the LS7366R integrated circuit data sheet for details to understand options, features and configurations. Failure to review the data sheet may result in a loss of understanding of how to configure and use this device.

As a difference between the LS7366R counter and other SPI devices, the LS7366R does not use variables, but instead relies on a function block to provide access to counter functionality in the ladder diagram project.

When the LS7366R is configured, click OK to close the LS7366R Properties dialog # 2. It is now listed in the LS7366R Properties dialog #1. Click OK to close the LS7366 Properites dialog #1.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The SPI port is now installed and ready to be used and additional SPI devices may be installed and used in the ladder diagram.


LS7366R Properties

SPI Properties
SPI Port: SPI0
CS Output: GPIO13

Quadrature Mode
- ( ) Non-quadrature, (A=CLK, B=DIR)
- ( ) X1
- ( ) X2
- (●) X4

Count mode
- (●) Free-running
- ( ) Single-cycle
- ( ) Range-limit
- ( ) Modulo-n

Index Mode
- (●) Disable index
- ( ) Load CNTR
- ( ) Reset CNTR
- ( ) Load OTR
- ( ) Asynchronous Index
- (●) Synchronous Index

Clock Filter
- (●) Div by 1
- ( ) Div by 2

LFLAG / DFLAG
- [✓] Flag on IDX
- [ ] Flag on CMP
- [ ] Flag on BW
- [ ] Flag on CY

Figure 15-6

LS7366R Configuration Parameters

All modes are controlled by the hardware settings listed. Functionality is achieved using a function block in the EZ LADDER Toolkit.

Quadrature Mode:

Non Quadrature (A=CLK, B=DIR)
A pulse on the A input will increment the counter or decrement the counter based on the B input.

X1
The A and B inputs are used in X1 mode for use with biphase encoders. The count value changes once for each biphase cycle.

X2
The A and B inputs are used in X2 mode for use with biphase encoders. The count value changes 2 times X1 mode given the same input signal.

X4
The A and B inputs are used in X4 mode for use with biphase encoders. The count value changes with each input transition, 4 times faster than X1 given the same input signal.

Count Mode:

Free Running
When counting pulses, the counter will continue to count in either direction and wrap if the count goes larger (or smaller) than the standard integer (32 bit).

Single Cycle
When counting pulses, the counter will stop counting in either direction if the count goes larger (or smaller) than the standard integer (32 bit). A Reset or Load is required to restart counting.

Range Limit
Counting range is limited between zero (0) and the PD (DTR) input on the CNTR_LS7366R function block. The LD function block input must be used to load the DTR (one scan cycle).

Modulo N
The counter value will be equal to the value of the input signal divided by the value loaded in DTR, plus 1 (DTR+1). If DTR is 1, then the count will equal the input signal divided by 2 or will count at 1/2 the rate of the input signal.

Index Mode:

Disable Index
The device's Index input will have no affect on operation.

Load CNTR
Configures the device's Index input to act as a *load counter.* This will load the value of the function block input PD (DTR) as the actual count.

Reset CNTR
Configures the device's Index input to act as a *reset counter.* This will reset the actual counter to zero.

Load OTR
Configures the devices Index input to transfer the actual count into the OTR register. The OTR register is a temporary register for storing the count.

Asynchronous Index
Asynchronous index mode. Valid in all modes.

Synchronous Index
Synchronous index mode. Only valid in quadrature mode.

Clock Filter:

Divide by 1
The clock input to the device is divided by 1 to create a filter frequency. This filter frequency must be at least 4 times larger than the frequency on the device A input.

Divide by 2
The clock input to the device is divided by 2 to create a filter frequency. This filter frequency must be at least 4 times larger than the frequency on the device A input.

LFLAG / DFLAG:

Flag on IDX
This check box enable the index flag bit that is output on the status register (ST of the CNTR_LS7366R function block).

Flag on CMP
This check box enable the compare flag bit that is output on the status register (set if DTR = actual count).

Flag on BW
This check box enable the borrow flag bit that is output on the status register (set if counter wraps negative (borrow)).

Flag on CY
This check box enable the borrow flag bit that is output on the status register (set if counter wraps positive (carry)).

Using the LS7366R in the Ladder Diagram Project

To gain the functionality of the SPI LS7366R counter integrated circuit, you must use the CNTR_LS7366R function block. This function block has multiple inputs and outputs. These inputs and outputs can function in different modes based on the configuration of the actual LS7366R in the ladder diagram projects.

It is important to reference the LS7366R data sheet for operation modes and to understand registers. A thorough understanding of the LS7366R is required to properly configure and use the device correctly.

For details on the use of the CNTR_LS7366 function block, refer to **Chapter 24 - Function Reference**.

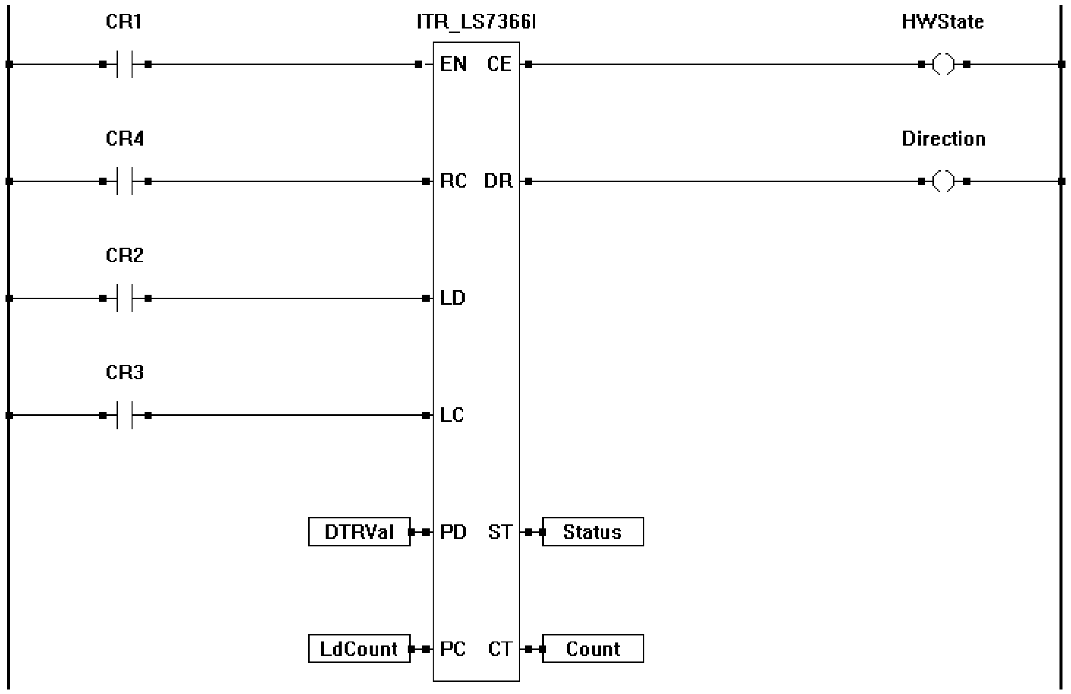


Figure 15-7

MCP3204 4 Channel 12 Bit Analog to Digital Converter

The MCP3204 is a 12 bit, 4 channel analog to digital converter integrated circuit with an SPI interface. EZ LADDER Toolkit has built-in software support for using this device on an SPI port.

The MCP3204 is a hardware device and requires additional circuitry and knowledge to interface it an EZ LADDER supported target. This chapter discusses the basics of using the MCP3204 in the ladder diagram and minor references to hardware when needed.

MCP3204 / SPI support is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if SPI devices are supported.

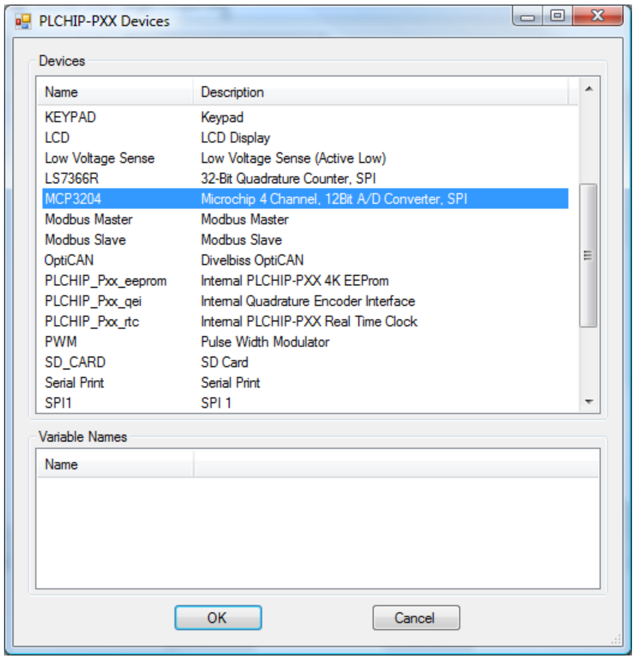
Installing the MCP3204 in the Ladder Diagram Project

To be able to use the MCP3204 in an EZ LADDER Toolkit ladder diagram project, the MCP3204 must first be installed and configured. As the PLC on a Chip™ is the most commonly used target for the MCP3204, it will be used as an example to install and configure the MCP3204.

The MCP3204 is configured using the Project Settings. Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If an MCP3204 device were installed, it would be listed in the *Devices pane* under the Bus\SPI section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the MCP3204. Figure 15-8 shows the Target's Devices window.

The SPI port must be installed individually or no SPI ports will show available in later drop down configuration menus.



Name	Description
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI1	SPI 1

Figure 15-8

Click **OK**. The MCP3204 Properties dialog will open. Ths dialog selects the SPI Port and Chip Select to be used for this MCP3204 device. See Figure 15-9.

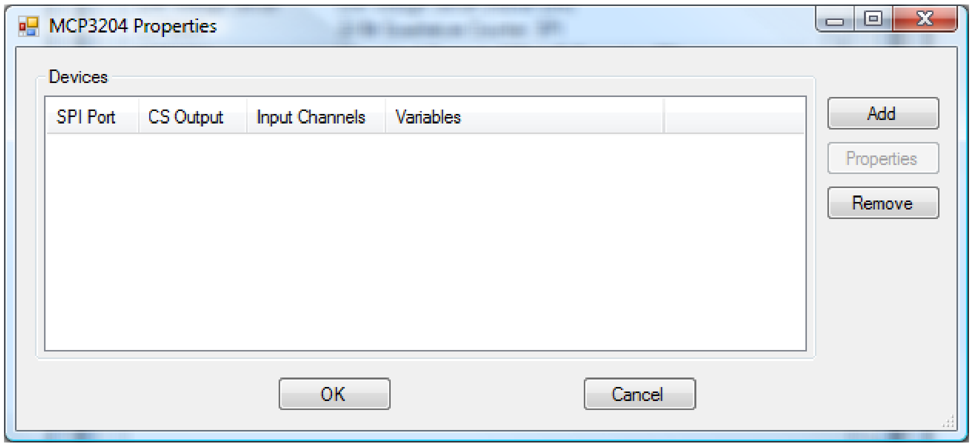


Figure 15-9

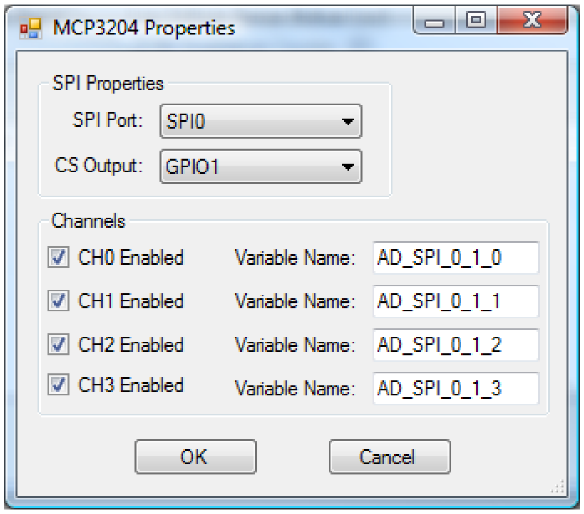
Multiple MCP3204 devices may be added to an SPI port provided that each device has a unique chip select output specified.

Click the ADD button. An additional MCP3204 Properties window will open.

Select the SPI port from the drop down menu and select the general purpose output pin (GPO) that will serve as this device's chip select (CS). See Figure 15-10. Any chip select pins reserved for structured text will not be visible in the drop-down menu.

With the SPI Port and CS Output selected, the Channel enable check boxes are now functional. Place a checkmark in the channels that are to be used by clicking in the check box next to CH0 to CH3. As a channel is enabled, an automatic Variable name is shown.

The variable names are automatically created when a channel is enabled. The name can be changed by typing the desired variable name in the Variable Name box for each channel.


MCP3204 Properties

SPI Properties
SPI Port: SPI0
CS Output: GPIO1

Channels

✓ CH0 Enabled	Variable Name: AD_SPI_0_1_0
✓ CH1 Enabled	Variable Name: AD_SPI_0_1_1
✓ CH2 Enabled	Variable Name: AD_SPI_0_1_2
✓ CH3 Enabled	Variable Name: AD_SPI_0_1_3

Figure 15-10

Refer to the MCP3204 integrated circuit data sheet for details on the MCP3204 and its limitations.

The MCP3204 analog input (analog to digital converter channel values) are always stored and can be accessed in the ladder diagram program by the variable (names) configured in the MCP3204 Properties # 2 dialog.

When the MCP3204 is configured, click OK to close the MCP3402 Properties dialog # 2. It is now listed in the MCP3204 Properties dialog #1. Click OK to close the MCP3204 Properites dialog #1.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The MCP3204 port is now installed and ready to be used in the ladder diagram.

This installation is to configure the MCP3204 as a device in EZ LADDER Toolkit and the target. The MCP3204 requires additional circuitry to amplifiy and or scale real world analog signals that are separate from the MCP3204 and EZ LADDER Toolkit.

Using the MCP3204 in the Ladder Diagram Project

The MCP3204 analog input (analog to digital converter channel values) are always stored and can be accessed in the ladder diagram program by the variable (names) configured in the MCP3204 Properties # 2 dialog.

During the installation process of the MCP3204, the variables should automatically be created as Integers. As the MCP3204 is a 12 bit analog to digital converter, the actual integer value for each channel will range from 0 to 4095 with 0 being 0 or the low end and 4095 being the maximum or high end. These variables may be used as inputs to function blocks in the ladder diagram program.

Figure 15-11 is an example ladder diagram using a variable from the MCP3204.

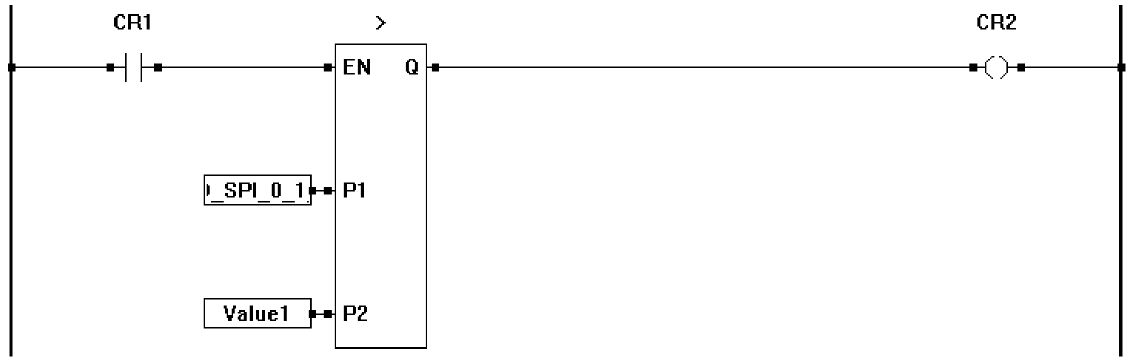


Figure 15-11

ADS8341 4 Channel 16 Bit Analog to Digital Converter

The ADS8341 is a 16 bit, 4 channel analog to digital converter integrated circuit with an SPI interface. EZ LADDER Toolkit has built-in software support for using this device on an SPI port.

The ADS8341 is a hardware device and requires additional circuitry and knowledge to interface it an EZ LADDER supported target. This chapter discusses the basics of using the ADS8341 in the ladder diagram and minor references to hardware when needed.

ADS8341 / SPI support is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if SPI devices are supported.

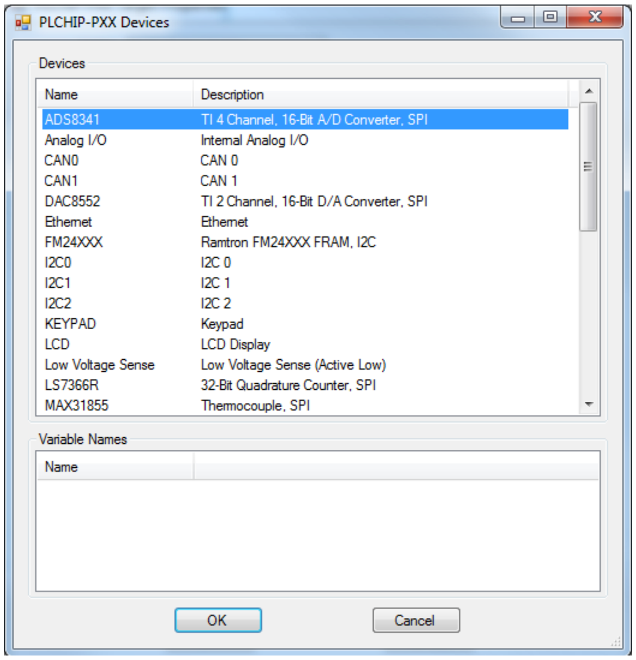
Installing the ADS8341 in the Ladder Diagram Project

To be able to use the ADS8341 in an EZ LADDER Toolkit ladder diagram project, the ADS8341 must first be installed and configured. As the PLC on a Chip™ is the most commonly used target for the ADS8341, it will be used as an example to install and configure the ADS8341.

The ADS8341 is configured using the Project Settings. Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If an ADS8341 device were installed, it would be listed in the *Devices pane* under the Bus\SPI section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the ADS8341. Figure 15-12 shows the Target's Devices window.

The SPI port must be installed individually or no SPI ports will show available in later drop down configuration menus.


PLCHIP-PXX Devices

Devices

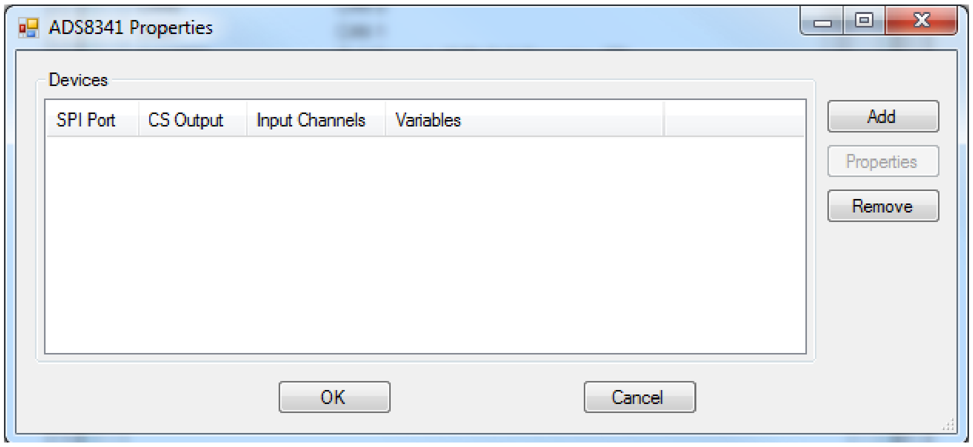
Name	Description
ADS8341	TI 4 Channel, 16-Bit A/D Converter, SPI
Analog I/O	Internal Analog I/O
CAN0	CAN 0
CAN1	CAN 1
DAC8552	TI 2 Channel, 16-Bit D/A Converter, SPI
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C1	I2C 1
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MAX31855	Thermocouple, SPI

Variable Names

Name

Figure 15-12

Click **OK**. The ADS8341 Properties dialog will open. Ths dialog selects the SPI Port and Chip Select to be used for this ADS8341 device. See Figure 15-13.


ADS8341 Properties

Devices

SPI Port	CS Output	Input Channels	Variables

Figure 15-13

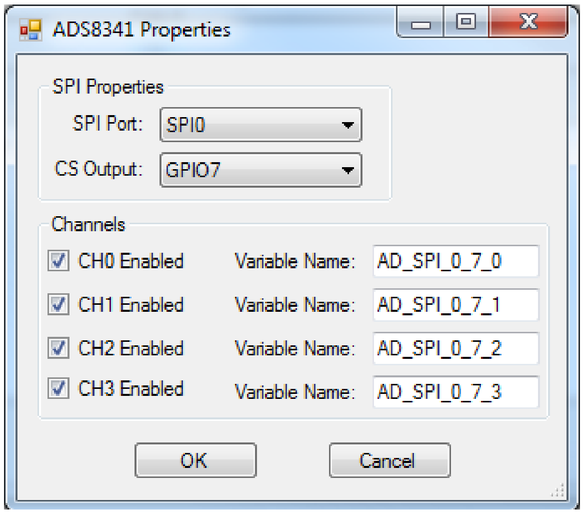
Multiple ADS8341 devices may be added to an SPI port provided that each device has a unique chip select output specified.

Click the ADD button. An additional ADS8341 Properties window will open.

Select the SPI port from the drop down menu and select the general purpose output pin (GPO) that will serve as this device's chip select (CS). See Figure 15-14. Any chip select pins reserved for structured text will not be visible in the drop-down menu.

With the SPI Port and CS Output selected, the Channel enable check boxes are now functional. Place a checkmark in the channels that are to be used by clicking in the check box next to CH0 to CH3. As a channel is enabled, an automatic Variable name is shown.

The variable names are automatically created when a channel is enabled. The name can be changed by typing the desired variable name in the Variable Name box for each channel.



SPI Port: SPI0
CS Output: GPIO7

Channels
[✓] CH0 Enabled Variable Name: AD_SPI_0_7_0
[✓] CH1 Enabled Variable Name: AD_SPI_0_7_1
[✓] CH2 Enabled Variable Name: AD_SPI_0_7_2
[✓] CH3 Enabled Variable Name: AD_SPI_0_7_3

Figure 15-14

Refer to the ADS8341 integrated circuit data sheet for details on the ADS8341 and its limitations.

The ADS8341 analog input (analog to digital converter channel values) are always stored and can be accessed in the ladder diagram program by the variable (names) configured in the ADS8341 Properties # 2 dialog.

When the ADS8341 is configured, click OK to close the ADS8341 Properties dialog # 2. It is now listed in the ADS8341 Properties dialog #1. Click OK to close the ADS8341 Properites dialog #1.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The ADS8341 port is now installed and ready to be used in the ladder diagram.

This installation is to configure the ADS8341 as a device in EZ LADDER Toolkit and the target. The ADS8341 requires additional circuitry to amplifiy and or scale real world analog signals that are separate from the ADS8341 and EZ LADDER Toolkit.

Using the ADS8341 in the Ladder Diagram Project

The ADS8341 analog input (analog to digital converter channel values) are always stored and can be accessed in the ladder diagram program by the variable (names) configured in the ADS8341 Properties # 2 dialog.

During the installation process of the ADS8341, the variables should automatically be created as Integers. As the ADS8341 is a 16 bit analog to digital converter, the actual integer value for each channel will range from 0 to 32767 with 0 being 0 or the low end and 32767 being the maximum or high end. These variables may be used as inputs to function blocks in the ladder diagram program.

Figure 15-15 is an example ladder diagram using a variable from the ADS8341.

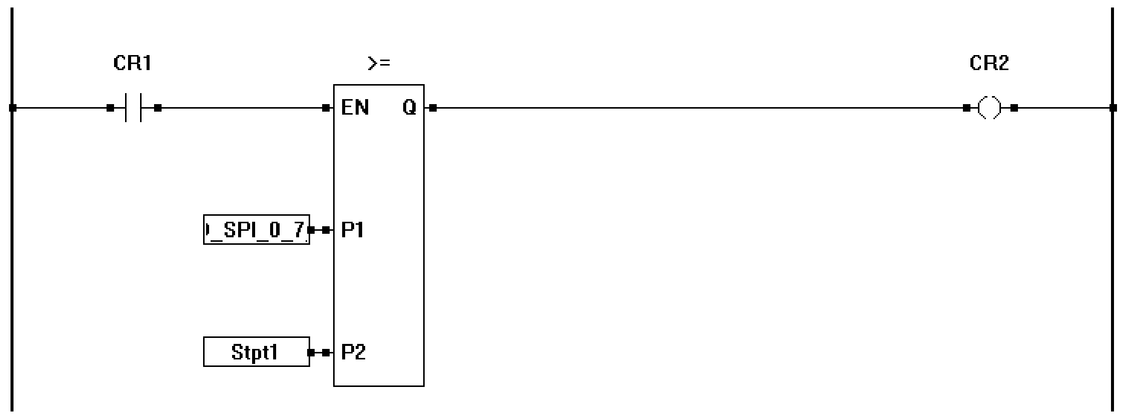


Figure 15-15

DAC8552 2 Channel 16 Bit Digital to Analog Converter

The DAC8552 is a 16 bit, 2 channel digital to analog converter integrated circuit with an SPI interface. EZ LADDER Toolkit has built-in software support for using this device on an SPI port.

The DAC8552 is a hardware device and requires additional circuitry and knowledge to interface it an EZ LADDER supported target. This chapter discusses the basics of using the DAC8552 in the ladder diagram and minor references to hardware when needed.

DAC8552 / SPI support is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if SPI devices are supported.

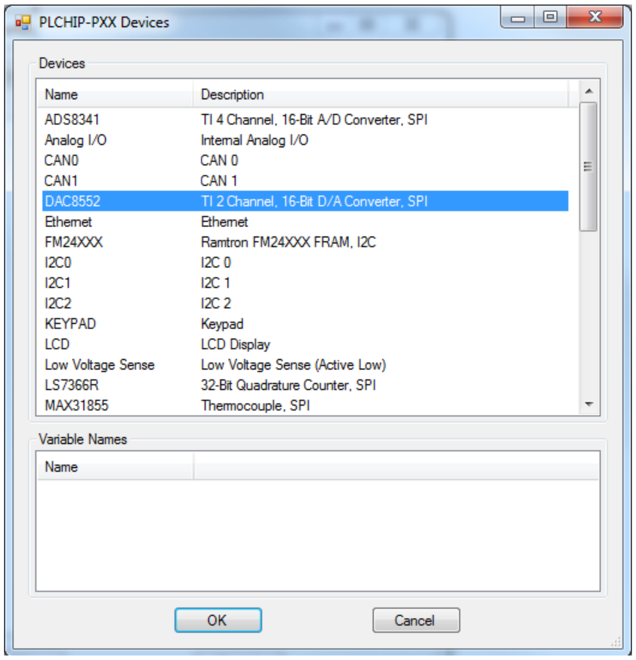
Installing the DAC8552 in the Ladder Diagram Project

To be able to use the DAC8552 in an EZ LADDER Toolkit ladder diagram project, the DAC8552 must first be installed and configured. As the PLC on a Chip™ is the most commonly used target for the DAC8552, it will be used as an example to install and configure the DAC8552.

The DAC8552 is configured using the Project Settings. Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If an DAC8552 device were installed, it would be listed in the *Devices pane* under the Bus\SPI section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the DAC8552. Figure 15-16 shows the Target's Devices window.

The SPI port must be installed individually or no SPI ports will show available in later drop down configuration menus.



Name	Description
ADS8341	TI 4 Channel, 16-Bit A/D Converter, SPI
Analog I/O	Internal Analog I/O
CAN0	CAN 0
CAN1	CAN 1
DAC8552	TI 2 Channel, 16-Bit D/A Converter, SPI
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C1	I2C 1
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MAX31855	Thermocouple, SPI

Figure 15-16

Click **OK**. The DAC8552 Properties dialog will open. Ths dialog selects the SPI Port and Chip Select to be used for this DAC8552 device. See Figure 15-17.

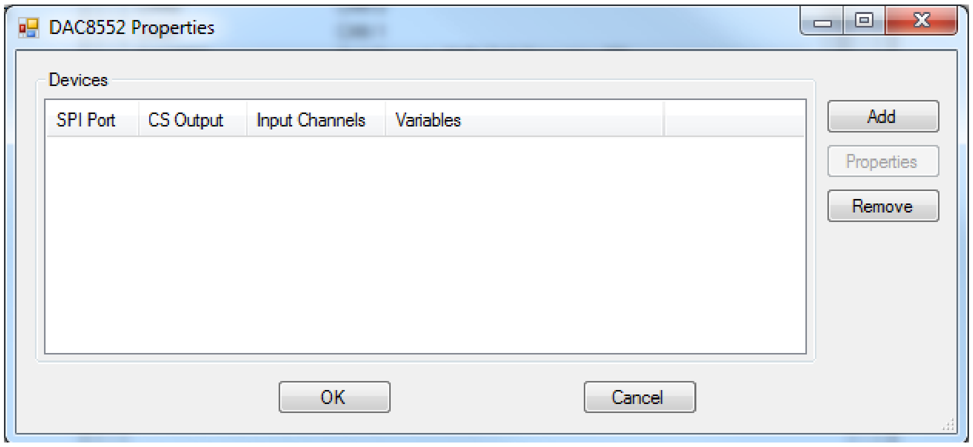


Figure 15-17

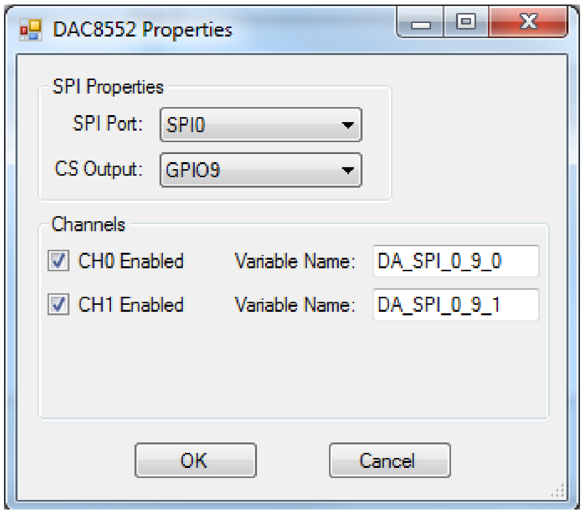
Multiple DAC8552 devices may be added to an SPI port provided that each device has a unique chip select output specified.

Click the ADD button. An additional DAC8552 Properties window will open.

Select the SPI port from the drop down menu and select the general purpose output pin (GPO) that will serve as this device's chip select (CS). See Figure 15-18. Any chip select pins reserved for structured text will not be visible in the drop-down menu.

With the SPI Port and CS Output selected, the Channel enable check boxes are now functional. Place a checkmark in the channels that are to be used by clicking in the check box next to CH0 to CH1. As a channel is enabled, an automatic Variable name is shown.

The variable names are automatically created when a channel is enabled. The name can be changed by typing the desired variable name in the Variable Name box for each channel.


DAC8552 Properties

SPI Properties

SPI Port: SPI0

CS Output: GPIO9

Channels

[✓] CH0 Enabled Variable Name: DA_SPI_0_9_0

[✓] CH1 Enabled Variable Name: DA_SPI_0_9_1

Figure 15-18

Refer to the DAC8552 integrated circuit data sheet for details on the DAC8552 and its limitations.

The DAC8552 analog output (digital to analog converter channel values) are always stored and can be accessed in the ladder diagram program by the variable (names) configured in the DAC8552 Properties # 2 dialog.

When the DAC8552 is configured, click OK to close the DAC8552 Properties dialog # 2. It is now listed in the DAC8552 Properties dialog #1. Click OK to close the DAC8552 Properites dialog #1.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The DAC8552 port is now installed and ready to be used in the ladder diagram.

This installation is to configure the DAC8552 as a device in EZ LADDER Toolkit and the target. The DAC8552 requires additional circuitry to amplifiy and or scale real world analog signals that are separate from the DAC8552 and EZ LADDER Toolkit.

Using the DAC8552 in the Ladder Diagram Project

The DAC8552 analog output (digital to analog converter channel values) are always stored and can be accessed in the ladder diagram program by the variable (names) configured in the DAC8552 Properties # 2 dialog.

During the installation process of the DAC8552, the variables should automatically be created as Integers. As the DAC8552 is a 16 bit digital to analog converter, the actual integer value for each channel will range from 0 to 65535 with 0 being 0 or the low end and 65535 being the maximum or high end. These variables may be used as outputs from function blocks in the ladder diagram program.

Figure 15-19 is an example ladder diagram using a variable from the DAC8552.

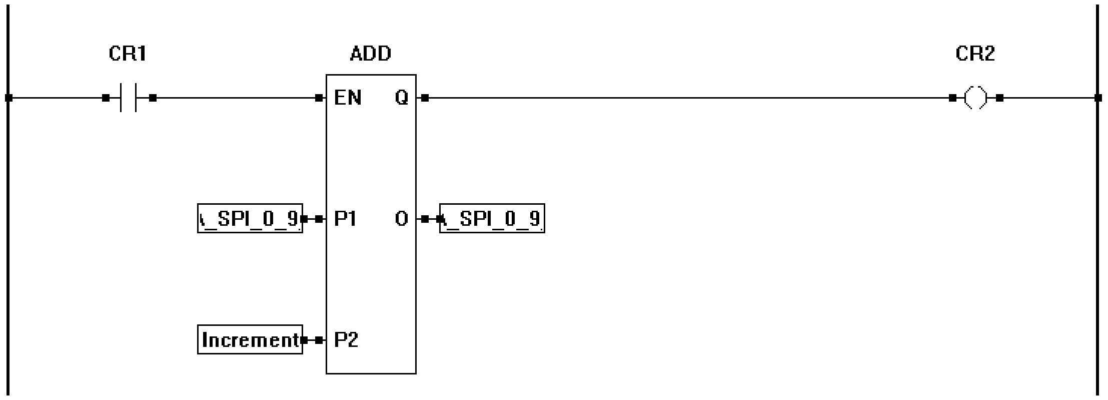


Figure 15-19

MAX31855 Single Channel Thermocouple Input

The MAX31855 is a single channel cold junction compensated thermocouple input integrated circuit with an SPI interface. EZ LADDER Toolkit has built-in software support for using this device on an SPI port. The suffix to the MAX31855 determines the thermocouple type and range of operation. Refer to the integrated circuit's datasheet.

The MAX31855 is a hardware device and requires additional circuitry and knowledge to interface it an EZ LADDER supported target. This chapter discusses the basics of using the MAX31855 in the ladder diagram and minor references to hardware when needed.

MAX31855 / SPI support is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if SPI devices are supported.

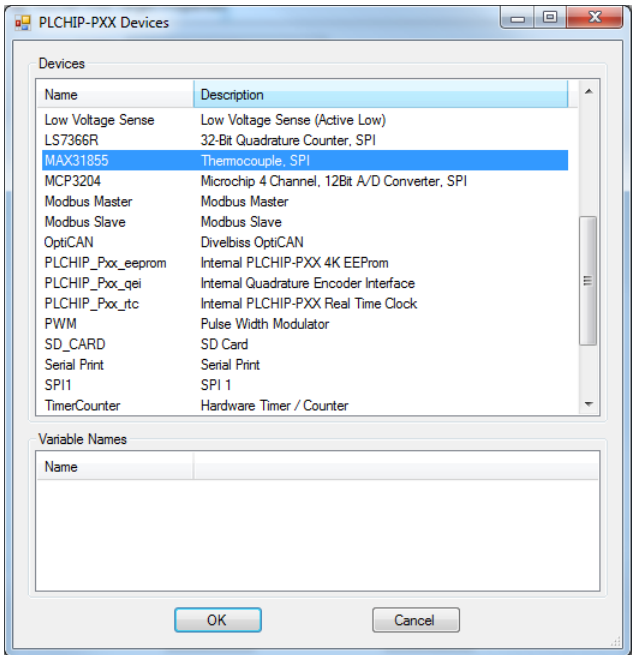
Installing the MAX31855 in the Ladder Diagram Project

To be able to use the MAX31855 in an EZ LADDER Toolkit ladder diagram project, the MAX31855 must first be installed and configured. As the PLC on a Chip^{TM} is the most commonly used target for the MAX31855, it will be used as an example to install and configure the MAX31855.

The MAX31855 is configured using the Project Settings. Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If an MAX31855 device were installed, it would be listed in the *Devices pane* under the Bus\SPI section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the MAX31855. Figure 15-20 shows the Target's Devices window.

The SPI port must be installed individually or no SPI ports will show available in later drop down configuration menus.



Name	Description
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MAX31855	Thermocouple, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI1	SPI 1
TimerCounter	Hardware Timer / Counter

Figure 15-20

Click **OK**. The MAX31855 Properties dialog will open. Ths dialog selects the SPI Port and Chip Select to be used for this MAX31855 device. See Figure 15-21.

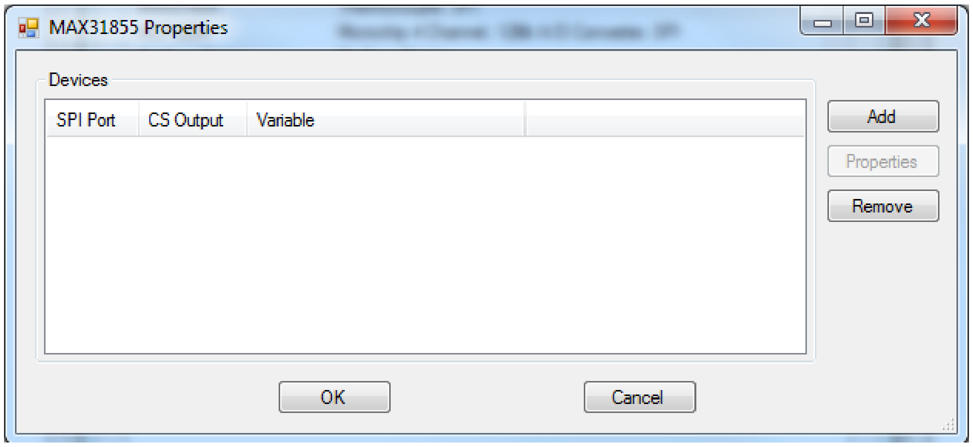


Figure 15-21

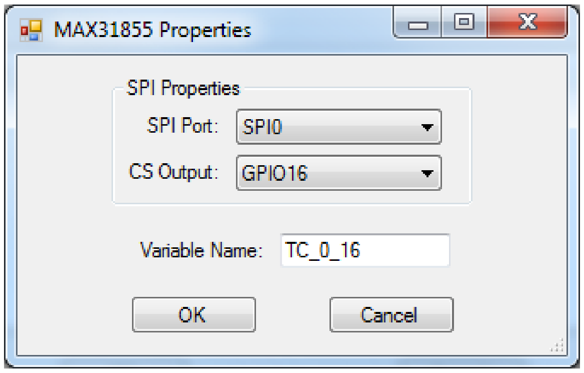
Multiple MAX31855 devices may be added to an SPI port provided that each device has a unique chip select output specified.

Click the ADD button. An additional MAX31855 Properties window will open.

Select the SPI port from the drop down menu and select the general purpose output pin (GPO) that will serve as this device's chip select (CS). See Figure 15-22. Any chip select pins reserved for structured text will not be visible in the drop-down menu.

With the SPI Port and CS Output selected, an automatic Variable name is shown.

The variable name is automatically created when SPI port and CS are selected. The name can be changed by typing the desired variable name in the Variable Name box.



SPI Port: SPI0
CS Output: GPIO16
Variable Name: TC_0_16

Figure 15-22

Refer to the MAX31855 integrated circuit data sheet for details on the MAX31855 and its limitations.

The MAX31855 thermocouple input values are always stored and can be accessed in the ladder diagram program by the variable (names) configured in the MAX31855 Properties # 2 dialog.

When the MAX31855 is configured, click OK to close the MAX31855 Properties dialog # 2. It is now listed in the MAX31855 Properties dialog #1. Click OK to close the MAX31855 Properites dialog #1.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The MAX31855 port is now installed and ready to be used in the ladder diagram.

This installation is to configure the MAX31855 as a device in EZ LADDER Toolkit and the target. The MAX31855 requires additional circuitry to control and filter real world thermocouple signals that are separate from the MAX31855 and EZ LADDER Toolkit.

Using the MAX31855 in the Ladder Diagram Project

The MAX31855 thermocouple input values are always stored and can be accessed in the ladder diagram program by the variable (names) configured in the MAX31855 Properties # 2 dialog.

During the installation process of the MAX31855, the variable should have been automatically be created as a real. As the MAX31855 is a thermcouple input, the actual value will be equal to the current sensed temperature in degrees celsius (°C). The type of thermocouple and range is dependent upon the actual part number of the MAX31855 used (model determines the thermocouple type and thermouple temperature range). This variable may be used as outputs from function blocks in the ladder diagram program.

Figure 15-23 is an example ladder diagram using a variable from the MAX31855.

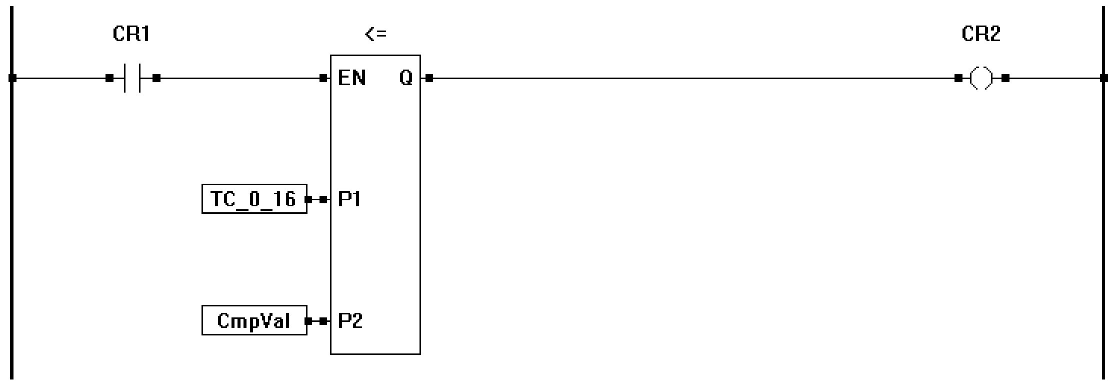


Figure 15-23

CHAPTER 16

I^{2}C Devices

This chapter provides basic information to understand how to install, configure and use the I2C Devices in the EZ LADDER Toolkit.

Chapter Contents

I^{2}C Overview

EZ LADDER Toolkit supports the use of I^{2}C Devices. These devices expand the capability of the P-Series PLC on a Chip™. Only supported I^{2}C devices may be used with the P-Series PLC on a Chip™ and not all P-Series PLC on a Chip targets will support these devices. Refer to **Chapter 23 - Hardware Targets** for complete target information including supported devices and commands.

For supported I2C devices, they must be connected to the P-Series PLC on a Chip™ correctly, using standard pull-up resistors (typically 1.5K Ohms). In addition, the device must be installed in EZ LADDER Toolkit.

The following I^{2}C devices are currently supported in EZ LADDER Toolkit and P-Series targets:

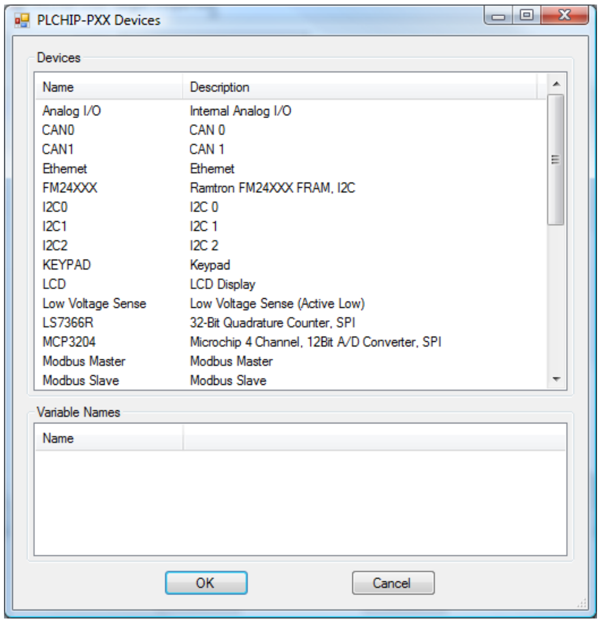
FM24XXX	Ramtron 24xxx Series FRAM

Installing an I^{2}C Bus in EZ LADDER

I^{2}C bus availability is based on actual hardware targets. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if I^{2}C is supported. I^{2}C devices must be connected to the P-Series PLC on a Chip™ per design guidelines for proper operation using pull-up resistors.

Using the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

Select the target and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If any I^{2}C bus is installed, it will be listed in the *Devices pane* under the Bus\I2C section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the I^{2}C buses (I2C0, I2C1, etc). Figure 16-1 shows the Target's Devices window.



Name	Description
Analog I/O	Internal Analog I/O
CAN0	CAN 0
CAN1	CAN 1
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C1	I2C 1
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave

Figure 16-1

Select **I2Cx** and click OK. The I2Cx bus will be installed. The Target's ***Devices*** window will close and the I2C bus is now listed in the *Target Properties* window in the Devices pane.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The I^{2}C bus is now installed and ready to be used and additional I^{2}C devices may be installed and used in the ladder diagram.

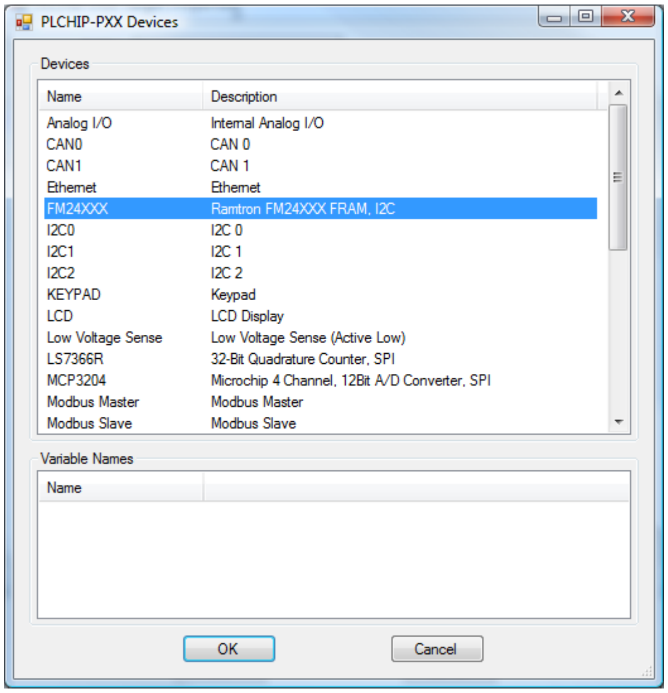
FM24XXX RAMTRON FRAM Storage Devices

F24XXX FRAM devices are memory storage devices based on FRAM technology. These FRAM devices are the memory used for retentive memory and/or used as non-volatile (EEPROM) storage on P-Series targets. As multiple sizes are available, the xxx in the part number represents the model / size.

To install an FM24XXX FRAM device, use the **Project Menu**, choose **Settings**. The Project Settings window will open as previously covered in **Chapter 4 - Configuring Targets**.

An I^{2}C bus must be installed for the FM24XXX to install and function. If an I2C bus is not installed, see **Installing an I^{2}C bus in EZ LADDER** earlier in this chapter.

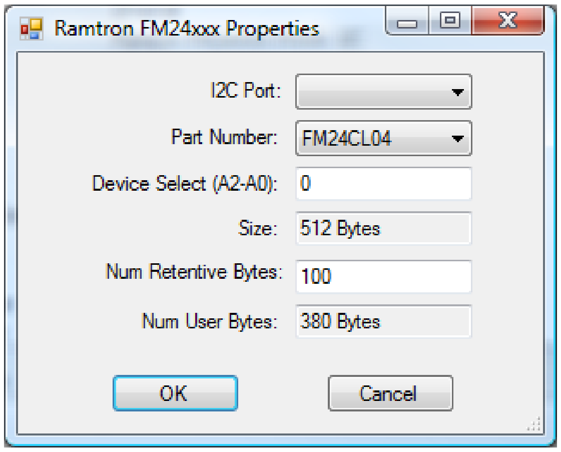
Select the target and click the PROPERTIES button. The *Target Properties* window will open. Click the ADD DEVICE button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the FM24XXX. Figure 16-2 shows the Target's Devices window.



Name	Description
Analog I/O	Internal Analog I/O
CAN0	CAN 0
CAN1	CAN 1
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C1	I2C 1
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave

Figure 16-2

Select **FM24XXX** and click OK. The Ramtron FM24XXX Properties Window will open. See Figure 16-3.


Ramtron FM24xxx Properties

I2C Port:

Part Number: FM24CL04

Device Select (A2-A0): 0

Size: 512 Bytes

Num Retentive Bytes: 100

Num User Bytes: 380 Bytes

Figure 16-3

Using the I2C Port Dropdown select box, select the I2C port that will interface to the Ramtron device. This bus should have been installed prior to this step.

Select the Ramtron Device part number from the Part Number Dropdown select box.

The Device Select (0) should not be edited unless multiple devices are installed on the same bus. Consult the factory for configuring and using multiple I2C devices on one I2C port for P-Series Targets.

The Num Retentive Bytes may be adjusted to reflect the amount of retentive memory required. See **Chapter 7 - Retentive Variables** and **Chapter 4 - Configuring Targets** for more details.

Click OK to install the FM24XXX device and close the Target's ***Devices*** window. The FM24XXX is now installed and should appear in the Target Properties window in the Devices pane under Bus/I2C/I2Cx/.

Click OK to close the Target Properties window and click OK to close the Project Settings window. Be sure to save the ladder diagram project. The FM24XXX device is now installed and ready to be used.

CHAPTER 17

Analog I/O

This chapter provides basic information on installing and using analog inputs and outputs. This chapter covers standard product and P-13 Series PLC on a Chip™ targets.

Chapter Contents

Analog Inputs

As analog inputs are a common requirement in today's control world, EZ LADDER Toolkit provides an easy to use interface to read analog inputs and then using the built-in function blocks, act on the analog input values.

Analog inputs provide a digital representation of an analog input signal. Analog inputs values are ranged as integers based on the resolution of the analog input. The on-board analog inputs of the P-Series PLC on a Chip™ are 12 bit resolution and the integer values that represent the signal ranges from 0 to 4095.

As the ladder diagram scans, it reads the analog signal level and digitizes it and converts it into an integer that represents it. For example, if the analog input signal can range from 0-5VDC, then the integer representation at 0V would be approximately 0 and at 5V would be approximately 4095. This integer number can then be scaled in the ladder diagram into engineering units.

The integer representation of the analog input is typically zero at the lower end (0V, 0mA, etc.) and 4095 at the high end of the scale (5VDC, 20mA). The highest allowed for the analog input resolution is hardware dependent (10 bit = 1023, 12 bit = 4095, 15 bit - 32767). SPI analog input devices may support different resolutions than the on-board 12 bit.

There are two ways to achieve analog input functionality in the EZ LADDER Toolkit hardware target.

One way is to add supported SPI bus analog input devices (integrated circuits). This requires additional hardware circuitry and interfacing. **See Chapter 15 - SPI Devices and Support** for a list of the supported devices, how to install and use them.

The seconds is using the on-board analog inputs (if supported).

All analog input support whether on-board or SPI device based are subject to the actual hardware target. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if analog inputs are supported.

Analog Input Installation / Configuration

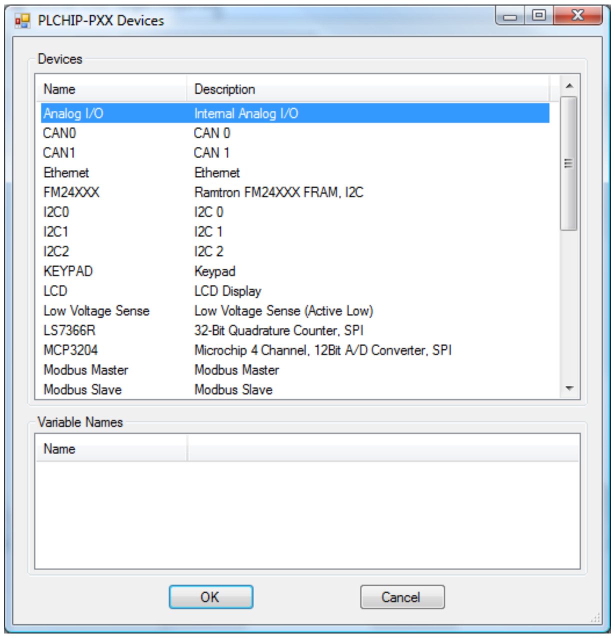
Some hardware targets require analog inputs to be installed and prior to being available in the EZ LADDER Toolkit ladder diagram project while others automatically configure the analog inputs in the EZ LADDER Toolkit when the target is selected.

Generally, off-the-shelf controllers that have analog inputs will automatically install in the EZ LADDER Toolkit and their variables are created automatically for the analog inputs.

P-Series PLC on a Chip™ targets (and others) typically require the analog inputs be installed in the Project Settings before they can be used in an ladder diagram project.

Installing Analog Inputs for PLC on a Chip™ Targets

Select the target (PLCHIP-PXX) and click the PROPERTIES button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If any Analog Inputs are installed, they will be listed in the *Devices pane* under the Internal/Analog I/O section. Click the ADD DEVICE button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the Analog I/O. Figure 17-1 shows the Target's Devices window.



Name	Description
Analog I/O	Internal Analog I/O
CAN0	CAN 0
CAN1	CAN 1
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C1	I2C 1
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave

Figure 17-1

Select **Analog I/O** and click OK. The *Internal Analog I/O Properties* Window will open. See Figure 17-2. Click the ADD INPUTS button to add analog inputs. A new *Add Analog Inputs* dialog will open. Select the analog input channels that are required (AI0 through AI7) (holding the CNTRL key will allow multiple selections) and click OK. The *Add Analog Inputs* dialog closes automatically and the analog inputs should now appear under the Input section of the *Internal Analog I/O Properties* window.

Click OK to close the Internal Analog I/O Properites window. The Analog I/O should now be listed in the Devices pane, under Internal. Click OK to close the Target Properties window.

Click OK to close the Project Settings window. Be sure to save the ladder diagram project. The analog inputs are now installed and ready to be used.

! EZ LADDER Toolkit automatically creates variables that represent the analog inputs. They are labeled AI0 through AI7 for analog input 1 through analog input 8 respectively.

! The P-Series PLC on a Chip Target supports one (1) on-board analog output and it also uses pin 12 (AI3). Therefore functionality on pin 12 may be configured as and analog input (AI3) or an analog output (AO0) but not both. Care should be taken when mapping analog I/O as to fit this into the requirements.

Removing Analog Inputs is accomplished in the same manner as adding inputs except the analog input(s) to remove is selected and the **REMOVE INPUTS** button is used in the Internal Analog I/O Properties window.

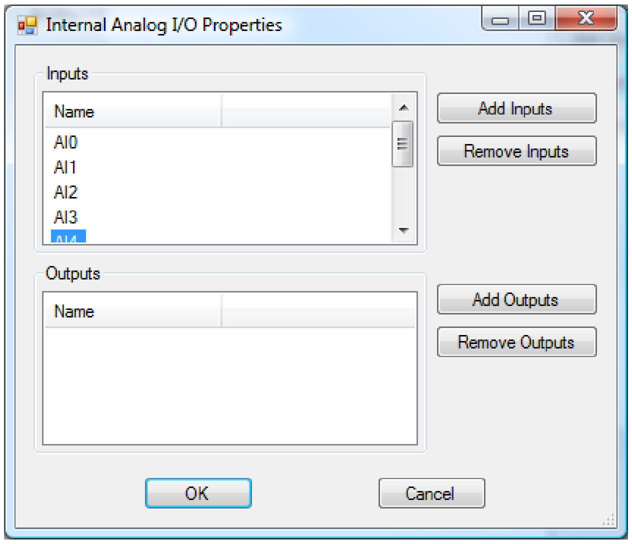


Figure 17-2

Using Analog Inputs in the Ladder Diagram Project

With the hardware target selected (and analog inputs installed if required), it is now simple to use these analog input readings in the ladder diagram project.

For each analog input, an integer variable exists that will be equal to the digital representation of the real world analog input signal. Typically, this number ranges from 0-4095 with zero representing the low end (0VDC, 0mADC, etc) and 4095 representing the upper end of the range (5VDC, 20mADC, etc.).

As these variables represent the analog inputs, they can be tied directly to function blocks that have integer inputs and if necessary these variables may be converted to REAL variables using the REAL function block. Figure 17-3 shows a ladder diagram using the analog input variable AI0 as an input to a function block.

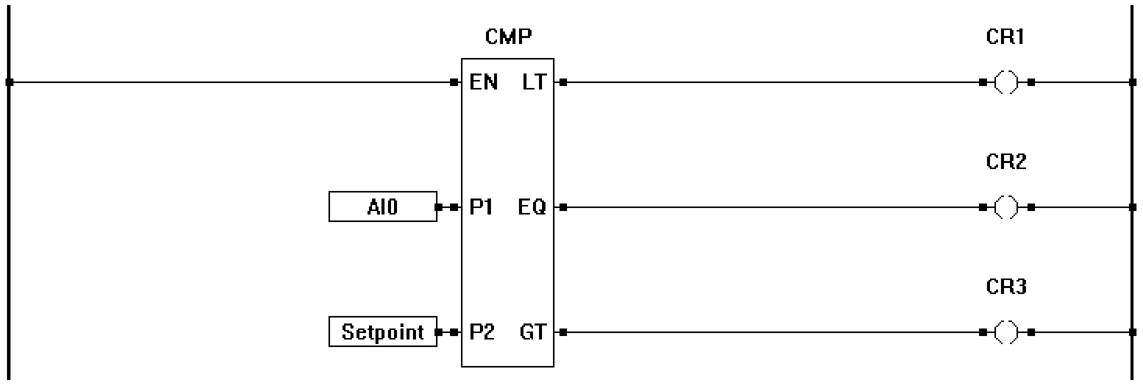


Figure 17-3

Averaging Analog Input Readings

As analog signals are susceptible to many environmental factors such as noise, etc, when connected to analog inputs, the analog input variables values will change frequently. Typically, analog inputs will toggle normally +/- one bit of resolution. To minimize the effect of this bit toggle and environmental conditions, it is recommended to average each analog input.

It is recommended to use the MAVG function block (Moving Average). When placing this block, you must enter the number of samples to be averaged.

The larger the number of samples, the more RAM is used and the slower the reaction time of the block output to input changes. Size the number of samples to give the best suited reaction time and to use the least amount of RAM needed accomplish to meet the operation specifications.

Figure 17-4 illustrates an analog input being averaged by the MAVG function block.

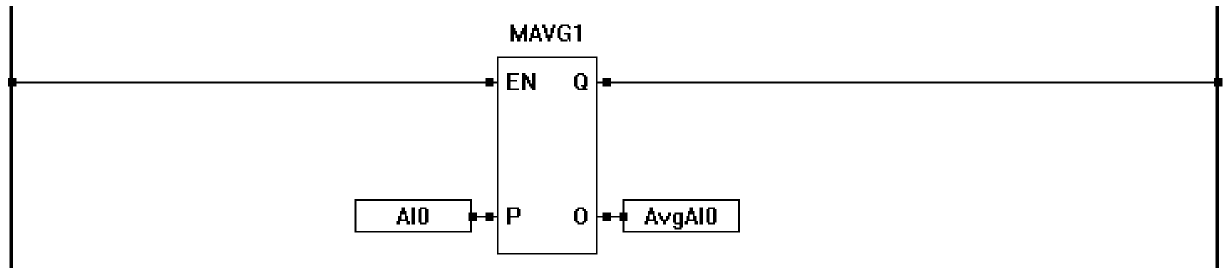


Figure 17-4

Scaling Analog Input Readings

It is often desirable to scale analog input reading to match the range of some control parameter such as pressure, etc. An analog input reading can be converted to another scale by using some math and conversion function blocks.

For scaling to operate properly, the analog input sensor must be sized correctly or the scaled analog input will not truly represent the range of operation.

Simple Scaling

If the analog input and sensor are sized accordingly (analog input 0-5VDC and the sensor = 0-100 PSI), then scaling is a simple matter. It is recommended that averaging be used prior to converting to any scale. Figure 17-5 illustrates a simple scaling circuit taking the analog input, averaging it and then converting it as above 0-100 PSI to represent 0-5VDC on the analog input.

It uses this formula:

Scaled Reading = ((Analog Input Reading / Max Resolution) X Max Scale)

in this case:

Scaled Reading = ((AI0 / 4095.0) X 100)

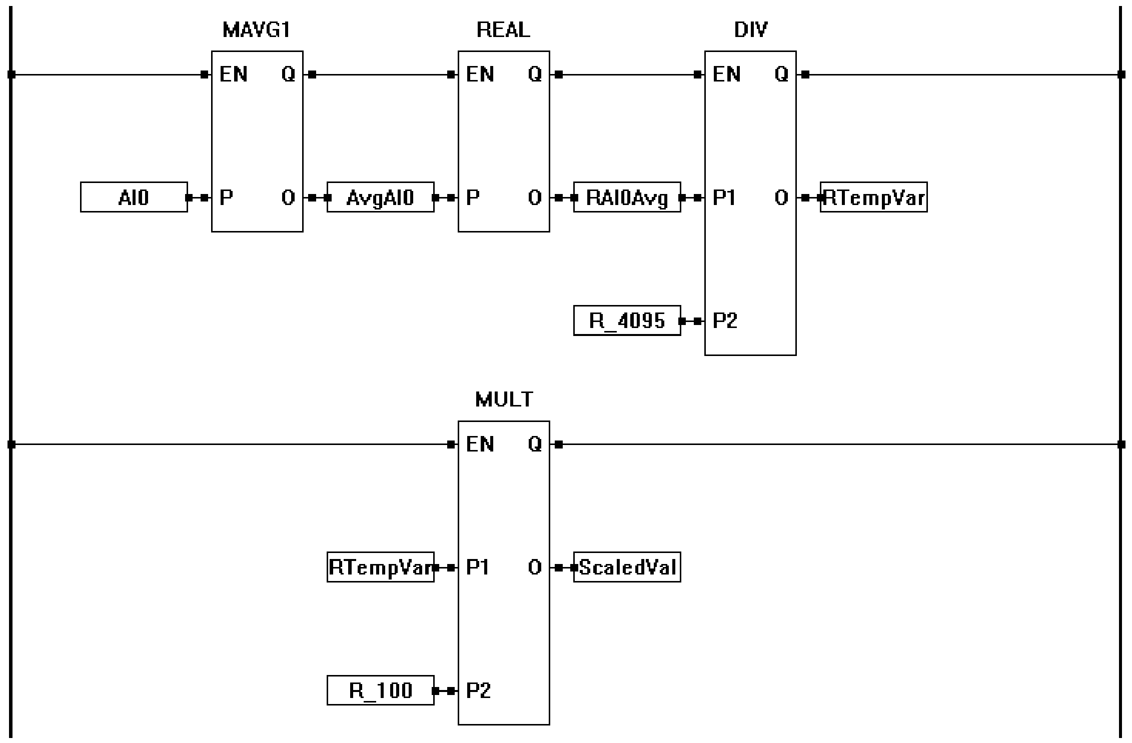


Figure 17-5

Advanced Scaling

If the analog input and sensor are designed with a range that does not start at zero as in the previous example, The analog input reading is still scalable, but requires a more complex formula. See Figure 17-6. It will take an analog input and scale it to 50 to 250 PSI.

It uses this formula:

Scaled Reading = (((Analog Input Reading / Max Resolution) X (Range Max - Range Min)) + Range Min)

in this case:

Scaled Reading = (((AI0 / 4095.0) X (250 - 50)) + 50)

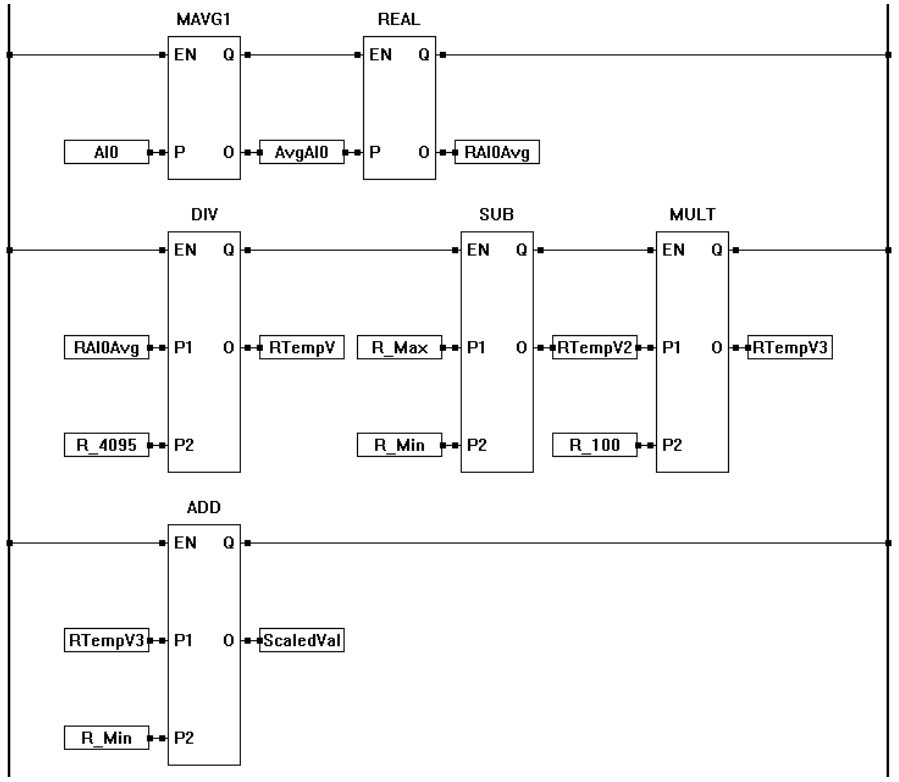


Figure 17-6

Analog Outputs

As analog outputs are a common requirement in today's control world, EZ LADDER Toolkit provides an easy to use interface to control analog outputs.

Analog outputs convert a digital value into an analog signal. Analog outputs values are ranged as integers based on the resolution of the analog input. The on-board analog output of the P-Series PLC on a Chip^{TM} is 10 bit resolution and the integer values that represent the signal ranges from 0 to 1023.

There are two ways to achieve analog output functionality in the EZ LADDER Toolkit hardware target.

One way is to add supported SPI bus analog output devices (integrated circuits). This requires additional hardware circuitry and interfacing. **See Chapter 15 - SPI Devices and Support** for a list of the supported devices, how to install and use them.

The seconds is using the on-board analog output(s) (if supported).

All analog output support whether on-board or SPI device based are subject to the actual hardware target. Refer to the target's User Manual or **Chapter 23 - Hardware Targets** to determine if analog outputs are supported.

The P-Series PLC on a Chip Target supports one (1) on-board analog output and it also uses pin 12 (AI3). Therefore functionality on pin 12 may be configured as and analog input (AI3) or an analog output (AO0) but not both. Care should be taken when mapping analog I/O as to fit this into the requirements.

Installing Analog Inputs for PLC on a Chip™ Targets

Select the target (PLCHIP-PXX) and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If any Analog Outputs are installed, they will be listed in the *Devices pane* under the Internal/Analog I/O section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the Analog I/O. Figure 17-7 shows the Target's Devices window.

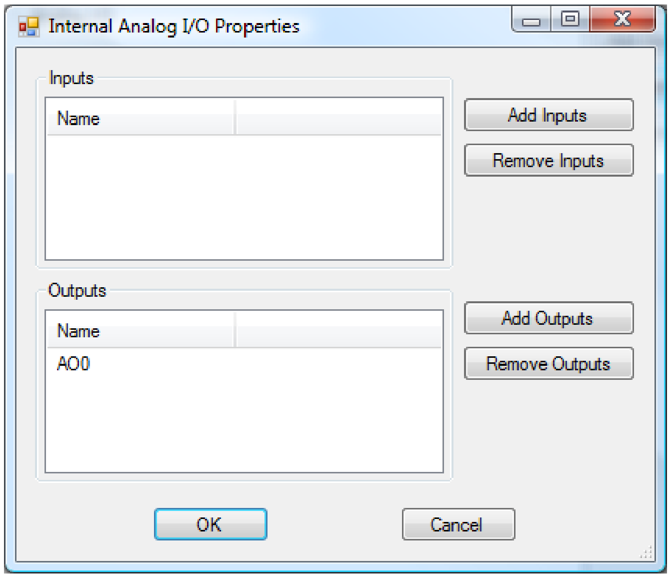


Figure 17-7

Select **Analog I/O** and click **OK**. The *Internal Analog I/O Properties* Window will open. See Figure 16-2. Click the **ADD OUTPUTS** button to add analog outputs. A new *Add Analog Outputs* dialog will open. Select the analog output channel(s) that are required (AOx) (holding the CNTRL key will allow multiple selections if necessary) and click **OK**. The *Add Analog Outputs* dialog closes automatically and the analog outputs should now appear under the Outputs section of the *Internal Analog I/O Properties* window.

Click **OK** to close the Internal Analog I/O Properites window. The Analog I/O should now be listed in the Devices pane, under Internal. Click **OK** to close the Target Properties window.

Click **OK** to close the Project Settings window. Be sure to save the ladder diagram project. The analog output(s) are now installed and ready to be used.

EZ LADDER Toolkit automatically creates variables that represent the analog outputs. They are labeled AOx for analog outputs.

Using Analog Outputs in the Ladder Diagram Project

With the hardware target selected (and analog outputs installed if required), it is now simple to use these analog outputs in the ladder diagram project.

For each analog output, an integer variable exists that will be the digital representation of the real world analog output signal. Typically, this number ranges from 0-1023 with zero representing the low end (0VDC, 0mADC, etc) and 1023 representing the upper end of the range (5VDC, 20mADC, etc.). Actual values and ranges are dependent upon the resolution of the analog output; in this case, the on-board analog output is 10 bit or 0-1023.

As these variables represent the analog outputs, they can be tied directly to function blocks that have integer outputs. As these function blocks *change* the variable values, the actual analog output's voltage or current will change accordingly.

Figure 17-8 shows a ladder diagram using the analog output variable AO0 as an output from a function block.

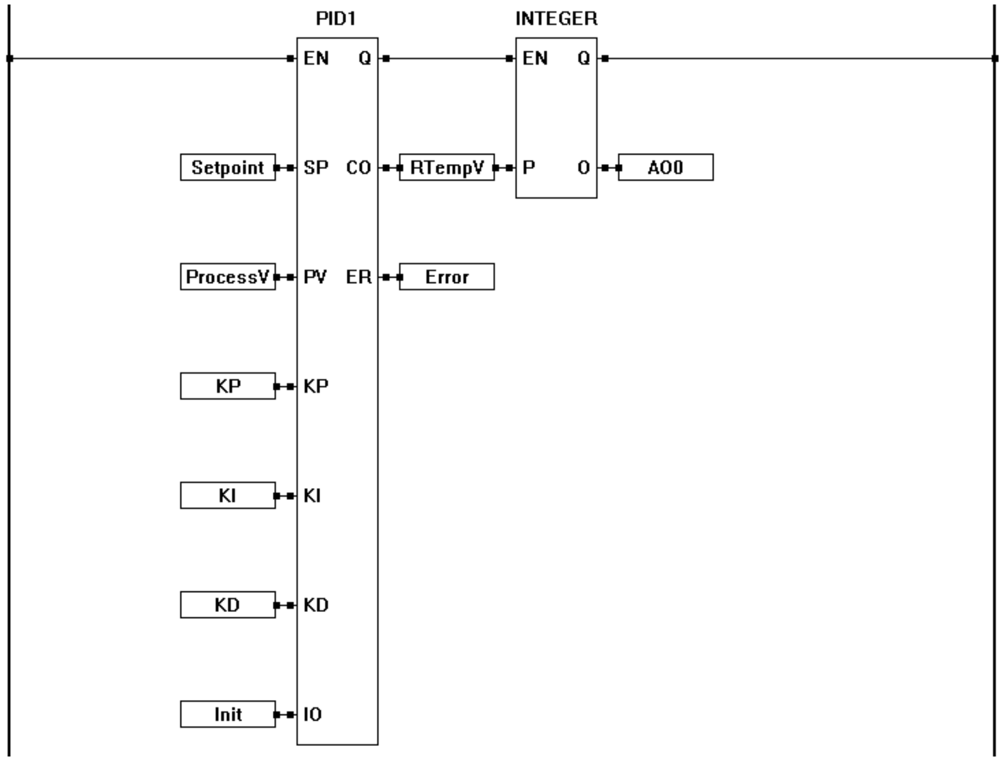


Figure 17-8

CHAPTER 18

Counters & Timers

This chapter provides basic information on installing and using on-board P-Series PLC on a Chip^{TM} Timers and Counters.

Chapter Contents

Counter - Timer Capture Inputs

The P-Series PLC on a Chip™ based products provide up to three hardware capture inputs that may be configured and utilized as either timers or counter inputs. These inputs are based on actual hardware inputs and internal frequencies, therefore, are more accurate than standard software timers and counters.

Additional EZ LADDER software Counter (CTU, CTD) and Timer (TON, TOF) functions exist. See **Chapter 24 - Function Reference**.

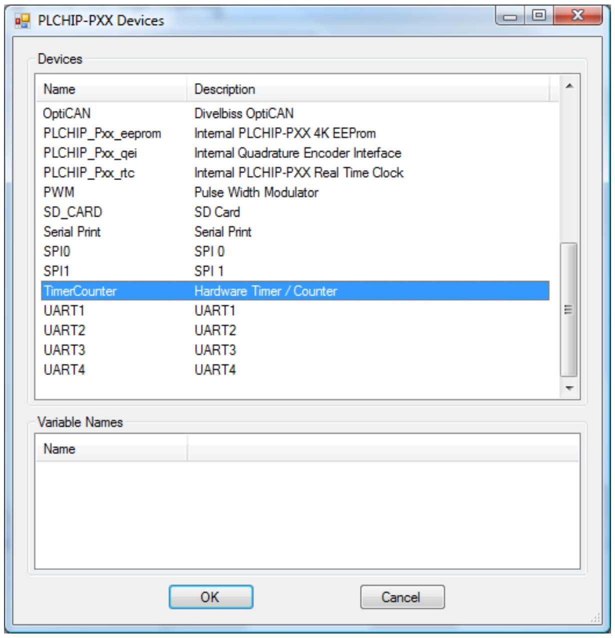
As this manual is a generic EZ LADDER Toolkit manual for P-Series PLC on a Chip™ target programming, the counter and timer capture inputs are covered. To determine if the actual hardware target (model) supports these inputs, refer to **Chapter 23 - Hardware Targets**.

All the counter - timer capture inputs are based off the PLC on a Chip™ CAPx.x pins. Depending upon the hardware target, only some or even none of the inputs may be available.

Installing Counter - Capture Inputs

Prior to using the TIMERCOUNTER function block, the actual capture input(s) must be installed in EZ LADDER Toolkit and configured for the operational mode desired. The examples shown are for the P-Series PLC on a Chip™. Other targets will operate and configure similarly.

Select the target (PLCHIP-PXX) and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If any of the Timer/Counter capture inputs are installed, they will be listed in the *Devices pane* under the Internal/TimerCounter section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the TimerCounter. Figure 18-1 shows the Target's Devices window.



Name	Description
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0
SPI1	SPI 1
TimerCounter	Hardware Timer / Counter
UART1	UART1
UART2	UART2
UART3	UART3
UART4	UART4

Figure 18-1

Select **TimerCounter** and click OK. The *Timer/Counter Properties* Window will open. See Figure 18-2.

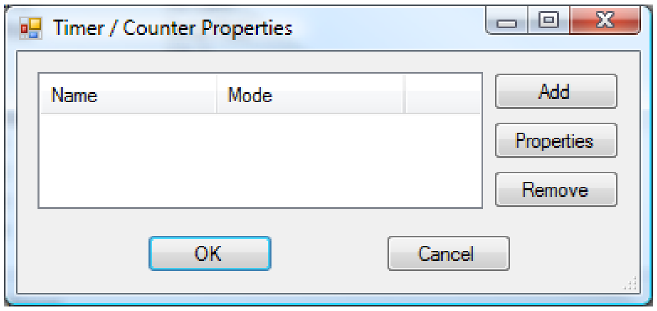


Figure 18-2

Click the ADD button to add capture inputs. A new *Select Timer / Counter Chanel* dialog will open. Select the capture input channels that are required (TmrCntr0 - TmrCntr2) (holding the CNTRL key will allow multiple selections) and click OK. See Figure 18-3.

The TmrCntrX (X=Channel) Properties for dialog will open. Using the drop down Mode menu, select the mode of operation for the timer-counter capture input. The choices are Free-running Timer, Timer or Counter. When selecting the mode as a free-running timer, no additional configuration is required. When configuring as either a timer or a counter, additional configuration is required by selecting the Timer Mode (or Counter Mode) and the Pin (capture pin). For the capture pin, refer to the target's hardware manual. See Figure 18-4.

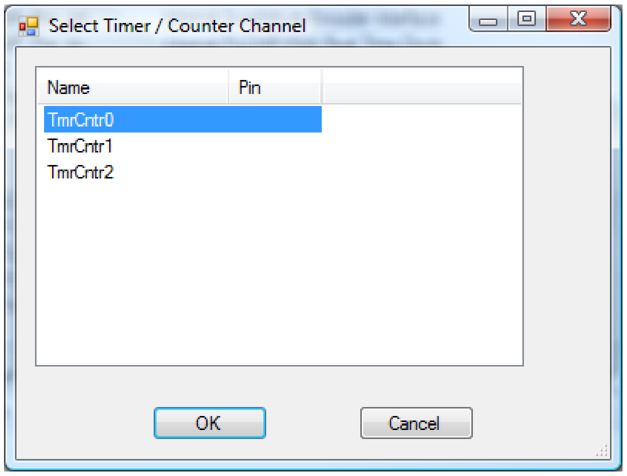
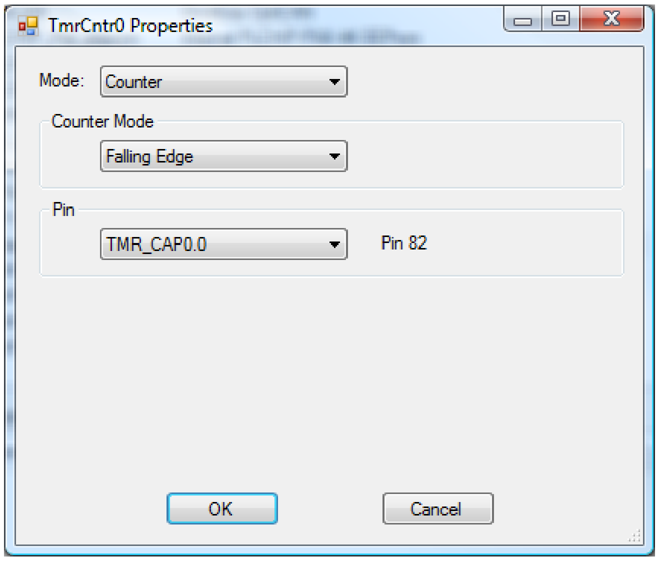


Figure 18-3


TmrCntr0 Properties

Mode: Counter

Counter Mode: Falling Edge

Pin: TMR_CAP0.0 Pin 82

Figure 18-4

Click OK to close the TmrCntrX Properites window. Click OK to close the Timer / Counter Properites window. The TimerCounter should now be listed in the Devices pane, under Internal. Click OK to close the Target Properties window.

Click OK to close the Project Settings window. Be sure to save the ladder diagram project. The timer / counter capture input(s) are now installed and ready to be used.

Capture Inputs Configured as Timers

Capture inputs may be configured as either standard timers or free-running timers and must be configured using the Project...Settings Menu as shown earlier this chapter.

Free-Running Timer

When configured as a free-running timer, the timer channel (capture input) may not be used for any other function and is based on a 1MHz reference clock. The TIMERCOUNTER function block is used to read the current value from the timer (capture input). See **Chapter 24 - Function Reference** for details on specific function blocks. When configured and the TIMERCOUNTER function block is enabled, the timer channel (capture input) will time based on 1MHz or one count for each microsecond. The timer may be reset by utilizing the reset (R) input.

When a timer capture channel reaches its maximum value, it will reset to zero and begin again. Care should be taken to not allow this to occur in the ladder diagram.

Standard Timer

When configured as a standard timer, the timer channel (capture input) may not be used for any other function and is based on a 96MHz clock. When using the capture input(s) as standard timers, they may be used and configured to measure either the input frequency or the period between input pulses.

The TIMERCOUNTER function block is used to read the current value from the timer (capture input). See **Chapter 24 - Function Reference** for details on specific function blocks. When configured and the TIMERCOUNTER function block is enabled, the timer channel (capture input) will provide either the actual input frequency on the capture input or the period between pulses on the catpure input.

The timer may be reset by utilizing the reset (R) input.

Capture Inputs Configured as Counters

Capture inputs may be configured as counters and must be configured using the Project...Settings Menu as shown earlier this chapter.

Capture inputs configured as counters may be configured to count on rising edge, falling edge or both edges. The Counter Mode (edge) is configured in the Project....Menu Settings. As timers, a input capture pin must be selected. Refer to the actual hardware target's datasheet or manual for identifying the proper capture pin.

When a counter capture channel reaches its maximum value, it will reset to zero and begin again. Care should be taken to not allow this to occur in the ladder diagram.

Quadrature Counter Inputs

In addition to timer-counter capture inputs, P-Series targets may support quadrature counter inputs. These inputs are ideal for connecting encoders for motion control.

As this manual is a generic EZ LADDER Toolkit manual for P-Series PLC on a Chip™ target programming, the Quadrature Counter inputs are covered. To determine if the actual hardware target (model) supports these inputs, refer to **Chapter 23 - Hardware Targets**.

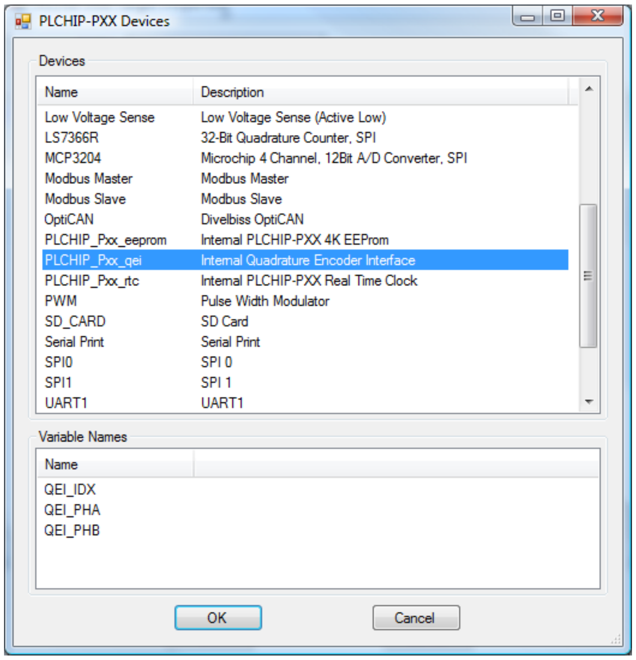
The qudrature counter consists of three inputs QEI_PHA (Phase A), QEI_PHB (Phase B) and QEI_IDX (Index). Pulses on these inputs cause internal hardware counters to count up, down or reset.

The internal hardware counters consist of the Position counter which holds the actual count of the input device connected to the A and B inputs and the Index Counter which hold the number of times the counter has passed the maximum allowed position (wrapped back to zero).

Installing Quadrature Counter Inputs

Prior to using the quadrature counter function block(s), the actual quadrature input(s) must be installed in EZ LADDER Toolkit and configured for the operational mode desired. The examples shown are for the P-Series PLC on a Chip™. Other targets will operate and configure similarly.

Select the target (PLCHIP-PXX) and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If any of the Quadrature Counter inputs are installed, they will be listed in the *Devices pane* under the Internal/PLCHIP_Pxx_qei section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find the PLCHIP_Pxx_qei. Figure 18-5 shows the Target's Devices window.

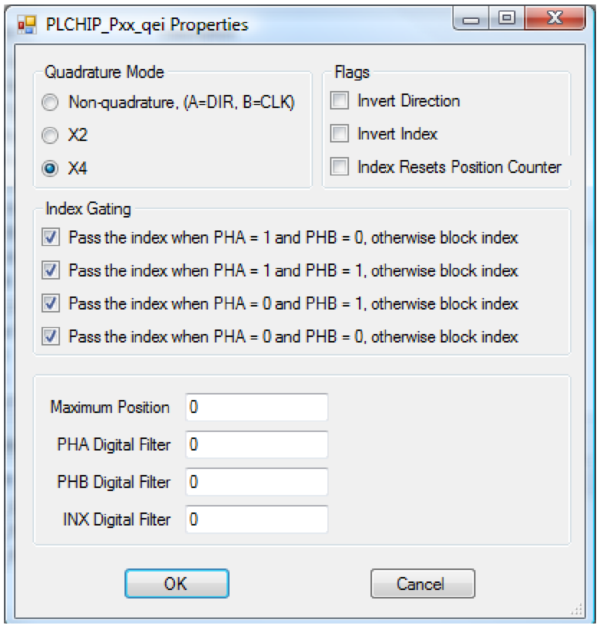


Name	Description
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave
OptiCAN	Divelbiss OptiCAN
PLCHIP_Pxx_eeprom	Internal PLCHIP-PXX 4K EEProm
PLCHIP_Pxx_qei	Internal Quadrature Encoder Interface
PLCHIP_Pxx_rtc	Internal PLCHIP-PXX Real Time Clock
PWM	Pulse Width Modulator
SD_CARD	SD Card
Serial Print	Serial Print
SPI0	SPI 0
SPI1	SPI 1
UART1	UART1

Name
QEI_IDX
QEI_PHA
QEI_PHB

Figure 18-5

Select **PLCHIP_Pxx_qei** and click OK. The *PLCHIP_Pxx_qei Properties* Window will open. See Figure 18-6.



PLCHIP_Pxx_qei Properties

Quadrature Mode
- ○ Non-quadrature, (A=DIR, B=CLK)
- ○ X2
- ● X4

Flags
- ☐ Invert Direction
- ☐ Invert Index
- ☐ Index Resets Position Counter

Index Gating
- ☑ Pass the index when PHA = 1 and PHB = 0, otherwise block index
- ☑ Pass the index when PHA = 1 and PHB = 1, otherwise block index
- ☑ Pass the index when PHA = 0 and PHB = 1, otherwise block index
- ☑ Pass the index when PHA = 0 and PHB = 0, otherwise block index

Maximum Position	0
PHA Digital Filter	0
PHB Digital Filter	0
INX Digital Filter	0

Figure 18-6

This PLCHIP_Pxx_qei properties window is used to configure specific parameters for the quadrature counter inputs.

Quadrature Mode

The quadrature mode sets how the quadrature counter inputs will operate.

Non-quadrature	Counter increments for each pulse on B (QEI_PHB) input. A (QEI_PHA) input sets the direction of count.
X2	X2 quadrature mode. Only two edges are counted per quadrature pulses on inputs A and B.
X4	X4 quadrature mode. All edges are counted per quadrature pulses on inputs A and B.

Flags

Optional flags may be configured for added versatility. These flags alter the way inputs are handled.

Invert Direction	Inverts the count direction.
Invert Index	Inverts the active state of the index input (QEI_IDX).
Index Resets Counter Position	A pulse on the Index input (QEI_IDX) will cause the Position Counter to reset.

Index Gating

Index Gating flags may be configured for added versatility. These flags alter the way the index pulses are handled base on conditions of the A and B inputs (Phase A, QEI_PHA and Phase B, QEI_PHB).

Care must be taken when altering the Index Gating flags as changes may cause undesired results.

Additional Settings

Maximum Position	This is the maximum position for the encoder (counter) position. In the forward direction, when the position counter exceeds this value, the index counter is incremented and the position counter is set to zero. In a reverse direction, when the position counter his zero, the index counters is decremented and the Position counter is set to the this value (maximum position).
PHA Digital Filter	Sampling counter for digital input filter for Phase A Input. If set to zero, the filter is disabled. When not zero, the value is the number of sample clocks that the input signal must remain in a new state (high/low) for the new state to be seen] as a valid state. The sample clock is 120MHz (8.33333ns).
PHB Digital Filter	Sampling counter for digital input filter for Phase B Input. If set to zero, the filter is disabled. When not zero, the value is the number of sample clocks that the input signal must remain in a new state (high/low) for the new state to be seen] as a valid state. The sample clock is 120MHz (8.33333ns).
INX Digital Filter	Sampling counter for digital input filter for Index Input. If set to zero, the filter is disabled. When not zero, the value is the number of sample clocks that the input signal must remain in a new state (high/low) for the new state to be seen] as a valid state. The sample clock is 120MHz (8.33333ns).

Click OK to close the PLCHIP_Pxx_qei Properites window. The PLCHIP_Pxx_qei should now be listed in the Devices pane, under Internal. Click OK to close the Target Properties window.

Click OK to close the Project Settings window. Be sure to save the ladder diagram project. The quadrature counter inputs are now installed and ready to be used.

Using the Quadrature Counter Inputs

With the quadrature counter inputs installed, they may be used in a ladder diagram. Three function blocks are provided that access the quadrature inputs: CNTR_PXX_QEI, CNTR_PXX_QEI_CMP and CNTR_PXX_QEI_VEL.

Using combinations of these function blocks provide maximum versatility in the ladder diagram to handle a multitude of applications.

The CNTR_PXX_QEI function block is used to read the current count (position counter), direction of travel, status and index count with optional reset control for the position counter and index counter.

The CNTR_PXX_QEI_CMP function block is used to set internal compare registers and then monitor the compare status of these registers. The position counter and index counter each have three (3) internal hardware compare registers that this function uses to compare values input to the function block as compare values to the actual counts of the position counter and index counter.

The CNTR_PXX_QEI_VEL function block is used to calculate a velocity based on the quadrature counter inputs.

See **Chapter 24 - Function Reference** for details on specific function blocks.

CHAPTER 19

Ethernet

This chapter provides basic information on installing and using Ethernet features.

Chapter Contents

Ethernet Overview

P-Series PLC on a ChipTM targes may support Ethernet connectivity. This Ethernet port may be used in two ways: as the programming port using EZ LADDER Toolkit and as a communication port (using Modbus).

As this manual is a generic EZ LADDER Toolkit manual for P-Series PLC on a ChipTM target programming, Ethernet connectivity is covered. To determine if the actual hardware target (model) supports ethernet, refer to **Chapter 23 - Hardware Targets**.

Installing Ethernet Support

By default, Ethernet ports are not enabled or configured on P-Series hardware targets. The Ethernet port must be installed and configured using the Project....Bootloader Menu.

The first step is to open an existing program or create a new program (a simple one-rung program). This program is required to switch EZ LADDER Toolkit from the EDIT mode to the RUN mode; which is required for using the Bootloader Menu option. Make sure the serial port is configured correctly in the Project...Settings menu. Refer to **Chapter 4 - Configuring Targets** and **Chapter 5 - Creating Ladder Diagram Projects**.

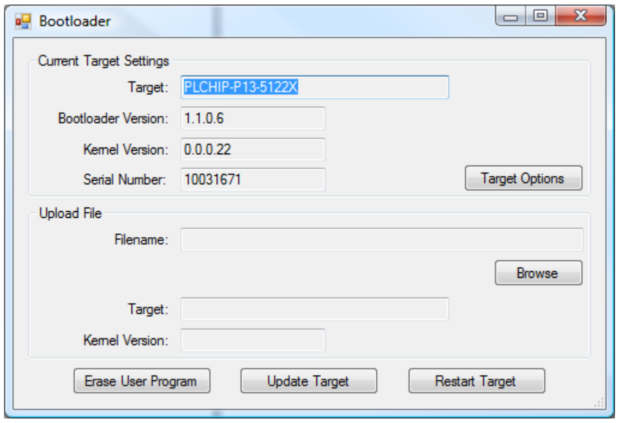
The Bootloader Menu option is only available when EZ LADDER Tookit is in the RUN mode.

Open or create the ladder diagram project and configure the serial port using the Project...Settings menu. Click the **MONITOR** (MON) button located on the toolbar. EZ LADDER will switch from the EDIT mode to the RUN mode. The toolbars will change appropriately.

In the RUN mode, select the ***Project*** menu and the select ***Bootloader***. EZ LADDER will now attemp to connect to the hardware target and initialize it's bootloader. During this time, you may see a small status window . If the Bootloader does not respond or an error is encountered, check the serial port settings and cables.

The bootloader is a factory installed utility program on all PLC on a ChipTM hardware targets. This utilility is used for configuring options on the target and to update or install target software kernels.

When the Bootloader utility responds, the Bootloader screen will automatically appear. See Figure 19-1.



Target: PLCHIP-P13-5122X
Bootloader Version: 1.1.0.6
Kernel Version: 0.0.0.22
Serial Number: 10031671

Figure 19-1

Click the TARGET OPTIONS button. A new Target Options window will open. This window had three tabs: Ethernet Options, USB Options and SD Card Options. See Figure 19-2.

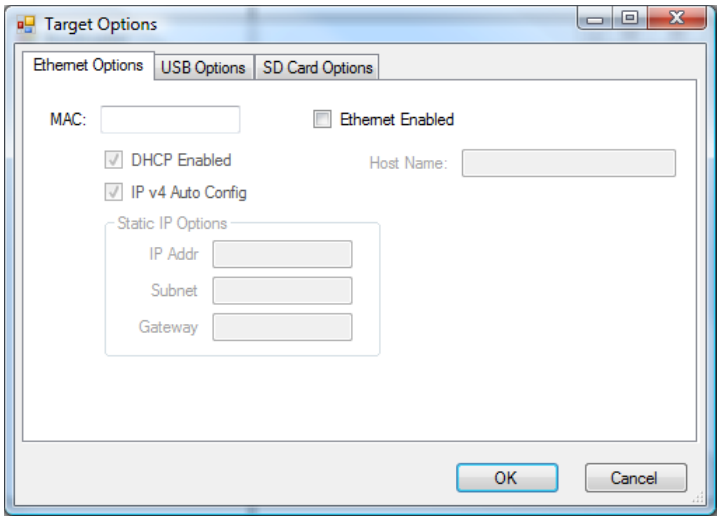


Figure 19-2

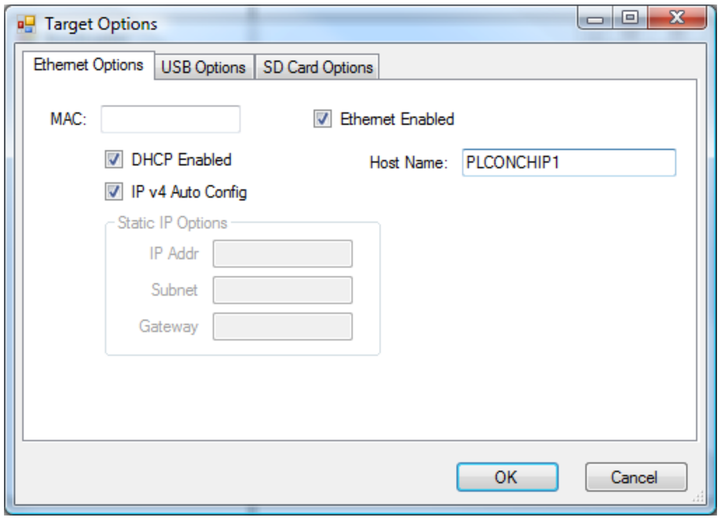
If not selected, select the **Ethernet Options** Tab. Click the Ethernet Enabled check-box to enable Ethernet.

The Ethernet configuration defaults to DHCP Enabled and IP v4 Auto Config enabled (the target gets it's IP address from the network's DHCP server. Static IP Addressing may also be configured.

DHCP Configuration

When configuring for receiving the IP address from the network, a Host name is recommended to identify the hardware target on the Ethernet network. See Figure 19-3. Enter a Host name in the *Host Name* box.

DHCP IP addressing is assigned by the network's DHCP server and therefore can be any address and is controlled (can change at will) by the DHCP server.



Host Name: PLCONCHIP1

Figure 19-3

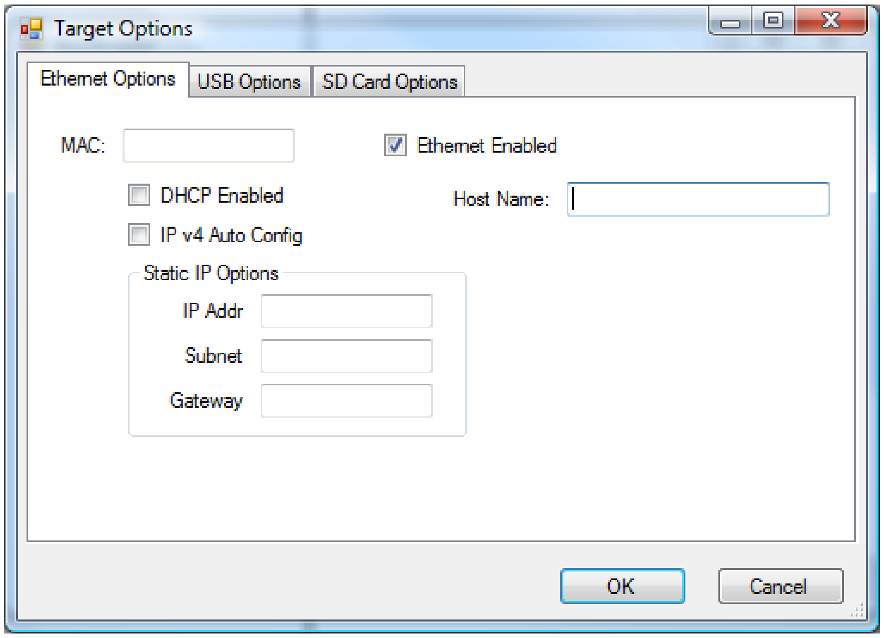
Click OK to accept the DHCP settings and close the window. Click RESTART TARGET to exit the Bootloader and force the software kernel to restart, accepting the changes. The Ethernet port is now configured to operate as the hardware target's programming port with the network's DHCP.

The MAC: field is factory set and should not be changed.

Static IP Configuration

To configure for a static IP mode, de-select the DHCP Enabled and IP v4 Auto Config check-boxes. Additional configuration items are required. See Figure 19-4.

When using the static IP mode, a Host Name is recommended to identify the hardware target on the Ethernet network.



MAC:
[✓] Ethernet Enabled
[ ] DHCP Enabled
Host Name:
[ ] IP v4 Auto Config
Static IP Options
IP Addr
Subnet
Gateway

Figure 19-4

The IP Address (IP Addr), Subnet (Subnet) and Gateway (Gateway) information must be entered into the appropriate boxes. Enter the information.

Generally, the Subnet (mask) is 255.255.255.0; however, this setting as with the IP Address and Gateway is network specific. This information may be obtained from you network administrator.

Click OK to accept the static IP settings and close the window. Click RESTART TARGET to exit the Bootloader and force the software kernel to restart, accepting the changes. The Ethernet port is now configured to operate as the hardware target's programming port with a static IP address.

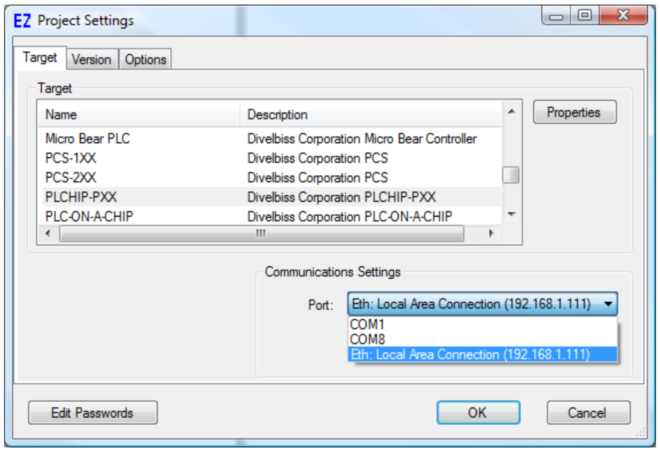
The MAC: field is factory set and should not be changed.

Ethernet as the Programming Port

By completing the configuration of the Bootloader Ethernet settings (DHCP or Static), the port is configured to be used as the hardware target's Programming Port for configuration and downloading ladder diagram programs.

For Modbus functionality, additional configuration items are required.

To use the Ethernet port as the programming port, in the ladder diagram's Project Settings, select Eth:XXXX from the Communications Settings drop-down box to configure the Ethernet as the port to use. See Figure 19-5.



Target

Name	Description
Micro Bear PLC	Divelbiss Corporation Micro Bear Controller
PCS-1XX	Divelbiss Corporation PCS
PCS-2XX	Divelbiss Corporation PCS
PLCHIP-PXX	Divelbiss Corporation PLCHIP-PXX
PLC-ON-A-CHIP	Divelbiss Corporation PLC-ON-A-CHIP

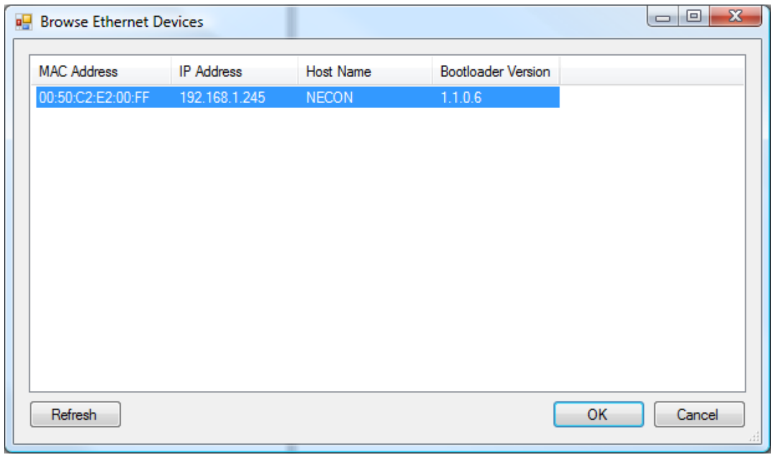
Communications Settings

Port: Eth: Local Area Connection (192.168.1.111)

COM1
COM8
Eth: Local Area Connection (192.168.1.111)

Figure 19-5

When connecting to the target (in RUN mode), a dialog box (Browse Ethernet Devices) will appear listing all the hardware targets found on the Ethernet network. Select the target to use and click OK. See Figure 19-6.



MAC Address	IP Address	Host Name	Bootloader Version
00:50:C2:E2:00:FF	192.168.1.245	NECON	1.1.0.6

Figure 19-6

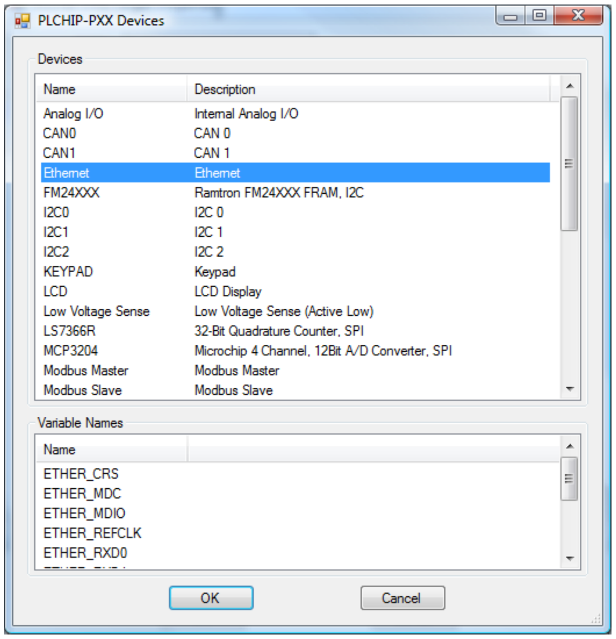
Ethernet Modbus Port

The Ethernet port may also be used as a Modbus communications port (Modbus Master or Slave). When using the Ethernet port as a Modbus communications port, addtional configuration is required.

As this manual is a generic EZ LADDER Toolkit manual for P-Series PLC on a Chip™ target programming, Ethernet connectivity is covered. To determine if the actual hardware target (model) supports ethernet, refer to **Chapter 23 - Hardware Targets**

Prior to using the Ethernet port for Modbus communications, the Ethernet port must be installed in the EZ LADDER project (this is different than previously installed using the Bootloader). It is installed using the Projects....Settings Menu.

Select the target (PLCHIP-PXX) and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. If Ethernet Port is installed, they will be listed in the *Devices pane* under the Internal/Ethernet section. Click the **ADD DEVICE** button. The Target's ***Devices*** window will open. All the available devices and features for the target are shown in the Devices section. Scroll down and find Ethernet. Figure 19-7 shows the Target's Devices window.



Name	Description
Analog I/O	Internal Analog I/O
CAN0	CAN 0
CAN1	CAN 1
Ethernet	Ethernet
FM24XXX	Ramtron FM24XXX FRAM, I2C
I2C0	I2C 0
I2C1	I2C 1
I2C2	I2C 2
KEYPAD	Keypad
LCD	LCD Display
Low Voltage Sense	Low Voltage Sense (Active Low)
LS7366R	32-Bit Quadrature Counter, SPI
MCP3204	Microchip 4 Channel, 12Bit A/D Converter, SPI
Modbus Master	Modbus Master
Modbus Slave	Modbus Slave

Name
ETHER_CRS
ETHER_MDC
ETHER_MDIO
ETHER_REFCLK
ETHER_RXD0

Figure 19-7

Select **Ethernet** and click **OK.** The *Target Properties* Properites window. Ethernet should now be listed in the Devices pane, under Internal. Click **OK** to close the Target Properties window.

Click **OK** to close the Project Settings window. Be sure to save the ladder diagram project. The Ethernet port now installed and ready to be used for Modbus communication.

Refer to **Chapter 13 - Modbus Networking** for details on Modbus communication and Modbus function blocks.

CHAPTER 20

SD Card Support

This chapter provides basic information to understand install and use SD Card features.

Chapter Contents

SD Card Support

EZ LADDER Toolkit provides features for installing and using SD Card features for P-Series PLC on a Chip^{TM} targets. The SD Card may be used to install and update EZ LADDER target kernels and/or ladder diagram programs. Future expansion will include the ability to log data to the SD Card.

As this manual is a generic EZ LADDER Toolkit manual for P-Series PLC on a Chip^{TM} target programming, SD Card Support is covered. To determine if the actual hardware target (model) supports the use of SD Cards, refer to **Chapter 23 - Hardware Targets**.

Installing SD Card Support

By default, SD Card features are not enabled or configured on P-Series hardware targets. The SD Card Support port must be installed and configured using the Project....Bootloader Menu.

The first step is to open an existing program or create a new program (a simple one-rung program). This program is required to switch EZ LADDER Toolkit from the EDIT mode to the RUN mode; which is required for using the Bootloader Menu option. Make sure the serial port is configured correctly in the Project...Settings menu. Refer to **Chapter 4 - Configuring Targets** and **Chapter 5 - Creating Ladder Diagram Projects**.

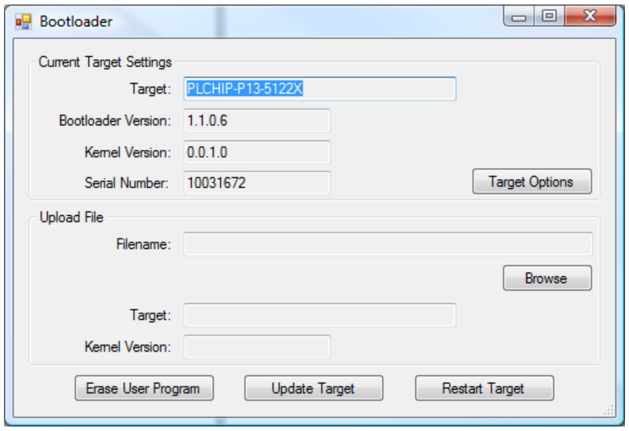
The Bootloader Menu option is only available when EZ LADDER Tookit is in the RUN mode.

Open or create the ladder diagram project and configure the serial port using the Project...Settings menu. Click the **MONITOR** (MON) button located on the toolbar. EZ LADDER will switch from the EDIT mode to the RUN mode. The toolbars will change appropriately.

In the RUN mode, select the ***Project*** menu and the select ***Bootloader***. EZ LADDER will now attemp to connect to the hardware target and initialize it's bootloader. During this time, you may see a small status window . If the Bootloader does not respond or an error is encountered, check the serial port settings and cables.

The bootloader is a factory installed utility program on all PLC on a Chip^{TM} hardware targets. This utilility is used for configuring options on the target and to update or install target software kernels.

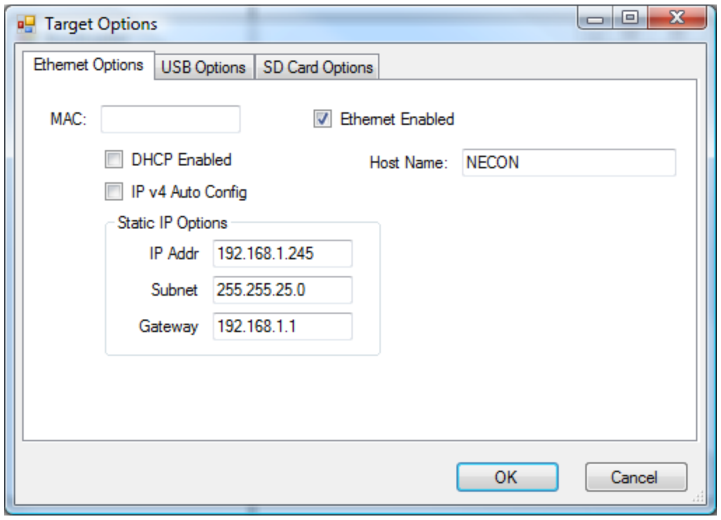
When the Bootloader utility responds, the Bootloader screen will automatically appear. See Figure 20-1.



Target: PLCHIP-P13-5122X
Bootloader Version: 1.1.0.6
Kernel Version: 0.0.1.0
Serial Number: 10031672

Figure 20-1

Click the TARGET OPTIONS button. A new Target Options window will open. This window had three tabs: Ethernet Options, USB Options and SD Card Options. See Figure 20-2.



MAC:

☑ Ethernet Enabled

☐ DHCP Enabled

Host Name: NECON

☐ IP v4 Auto Config

Static IP Options

IP Addr 192.168.1.245

Subnet 255.255.25.0

Gateway 192.168.1.1

Figure 19-2

Select the **SD Card Options** Tab.

To enable the SD Card, click (check) the **SD Card Enabled** check-box. This enables the SD Card Features in the target.

If you wish to allow kernel updates from an installed SD Card, click (check) the **Allow Kernel Updates** check-box. How kernels are installed or updated is covered later in this chapter.

If you wish to allow Ladder Diagram updates from an installed SD Card, click (check) the **Allow LD Updates** check-box. How ladder diagrams are installed or updated is covered later in this chapter.

Click OK to accept the SD Card settings and close the window. Click RESTART TARGET to exit the Bootloader and force the software kernel to restart, accepting the changes. The SD Card is now configured to operate as configured.

Using the SD Card

The SD Card Support must be installed using the Bootloader before any SD Card may be used.

As this manual is a generic EZ LADDER Toolkit manual for P-Series PLC on a Chip™ target programming, SD Card Support is covered. To determine if the actual hardware target (model) supports the use of SD Cards, refer to **Chapter 23 - Hardware Targets**.

For targets that support the SD Card (Secure Digital Card), it is typically plugged-in (or inserted) into a socket located on the hardware target.

The type of SD Card and socket is target dependent. Refer to the hardware target's User Manual for details on the type of SD Card supported and details for accessing and installing a supported SD Card.

Updating the Kernel and Ladder Diagram

An installed SD Card may be used to install or update a kernel or ladder diagram (or both). The SD Card must have a directory named: ***update***. The files to be installed or updated are located in the ***update*** directory of the SD Card.

If the kernel is to be udpated or installed, the actual target kernel file (.dat) must be copied or loaded into the ***update*** directory on the SD Card. This file can be found in the EZ LADDER kernel directory or other kernel files may used from other sources such as downloading from the website, etc. This file loading on the SD Card is done outside of EZ LADDER and the hardware target.

The kernel will only update from the SD Card when the kernel name (.dat) matches the kernel name installed on the hardware target and the version of the kernel on the SD CARD is newer. The kernel will install on a new target (without kernel installed already) if there is only one kernel file (only 1 xxx.dat) in the update directory.

If the ladder diagram is to be udpated or installed, the actual compiled ladder diagram file (.hex) must be copied or loaded into the ***update*** directory on the SD Card. This file is found where the actual ladder diagram (.dld) file is located. This file loading on the SD Card is done outside of EZ LADDER and the hardware target.

The compiled ladder diagram program (.hex) will only update from the SD Card when the filename (.hex) matches the program name already installed on the hardware target, the hardware target's installed kernel version is new enough to support the version the ladder program was compiled with and the ladder diagrams version and build numbers are different. This allows a program either newer or older to be installed (updated) from the SD Card if the conditions set here are met.

Additionally, if there is no ladder diagram installed on the target (blank) and there is only one .hex (compiled ladder diagram) file in the SD card's update directory and the installed target's kernel matches what is expected in the compile ladder diagram file (.hex) and the kernel is new enough to support the ladder diagram file (.hex), then the .hex file (ladder diagram) will in installed on the target.

Kernel and ladder diagram updates are performed only on power-up of the hardware target (after the SD Card has been installed).

To install an update, install the pre-loaded SD Card into the target's SD Card socket and cycle power. If the above conditions are met, the file(s) will be udpated on the target. The SD Card may be removed after the update.

CHAPTER 21

EZ LADDER Toolkit Reports

This chapter provides basic information to understand how to create and use EZ LADDER Toolkit project reports.

Chapter Contents

EZ LADDER Toolkit Reports

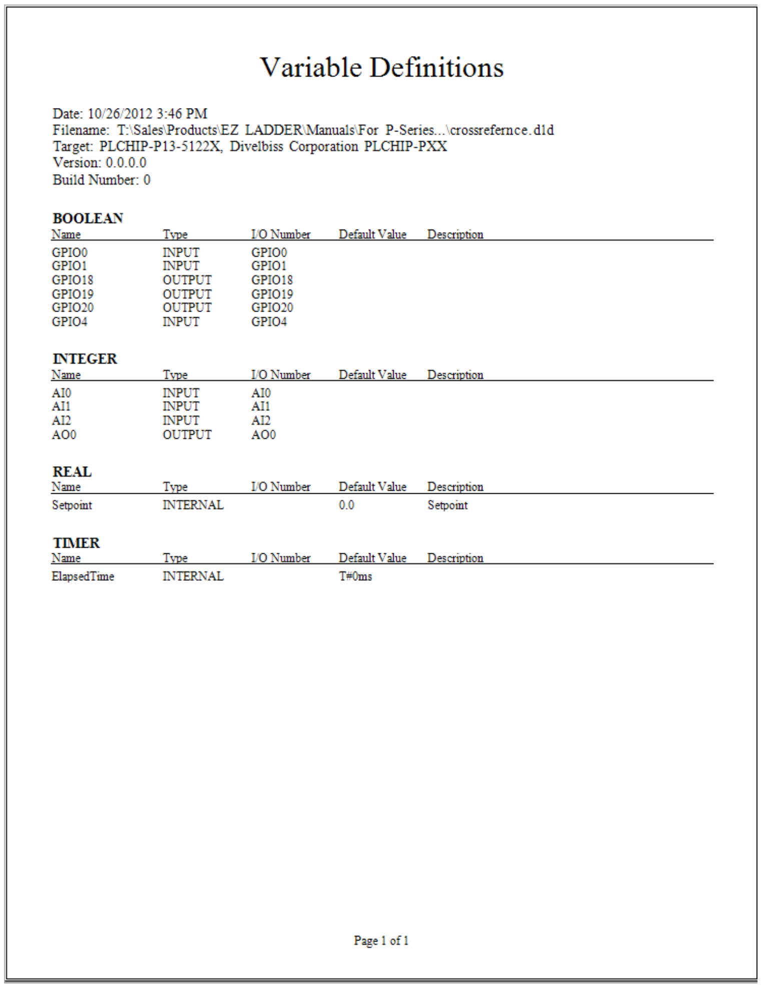
EZ LADDER Toolkit includes reporting features to aid in creation, troubleshooting and documenting ladder diagram projects. Each report, when generated, is viewable and printable.

There are two basic reports that can be generated: Variable Definitions and Cross References.

Variable Definitions Report

The variable definitions report provides a summary of all of the variables in the ladder diagram project. These variables are sorted by type for easy reference. For each variable, the report shows Name, Type, I/O Number, Default Value and its Description.

To generate and view this report, using the **Reports Menu**, select *Variable Definitions*. A report window will open displaying the generated report. Controls are available to change pages and print. Figure 20-1 is an example of the report that is seen or printed.



Variable Definitions

Date: 10/26/2012 3:46 PM
Filename: T:\Sales\Products\EZ LADDER\Manuals\For P-Series...\crossrefernce.dld
Target: PLCHIP-P13-5122X, Divelbiss Corporation PLCHIP-PXX
Version: 0.0.0.0
Build Number: 0

BOOLEAN

Name	Type	I/O Number	Default Value	Description
GPIO0	INPUT	GPIO0		
GPIO1	INPUT	GPIO1		
GPIO18	OUTPUT	GPIO18		
GPIO19	OUTPUT	GPIO19		
GPIO20	OUTPUT	GPIO20		
GPIO4	INPUT	GPIO4		

INTEGER

Name	Type	I/O Number	Default Value	Description
AI0	INPUT	AI0		
AI1	INPUT	AI1		
AI2	INPUT	AI2		
AO0	OUTPUT	AO0		

REAL

Name	Type	I/O Number	Default Value	Description
Setpoint	INTERNAL		0.0	Setpoint

TIMER

Name	Type	I/O Number	Default Value	Description
ElapsedTime	INTERNAL		T#0ms	

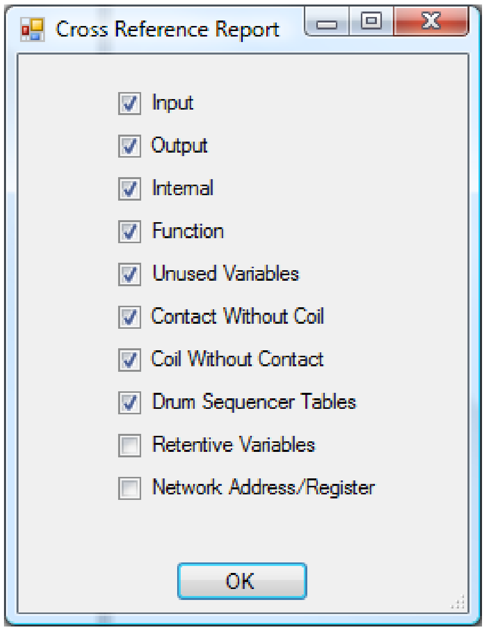
Page 1 of 1

Figure 20-1

Cross References Report

The Cross Reference Report provides a summary of the objects that are in the ladder diagram project. The project objects are sorted by the type of object. The actual types of objects and data to view is selected prior to generating the Cross Reference Report.

To generate and view this report, using the **Reports Menu**, select *Cross References*. The Cross Reference Report dialog box will open with the choices to what objects to include in the report. See Figure 17-2.



- [✓] Input
- [✓] Output
- [✓] Internal
- [✓] Function
- [✓] Unused Variables
- [✓] Contact Without Coil
- [✓] Coil Without Contact
- [✓] Drum Sequencer Tables
- [ ] Retentive Variables
- [ ] Network Address/Register

Figure 20-2

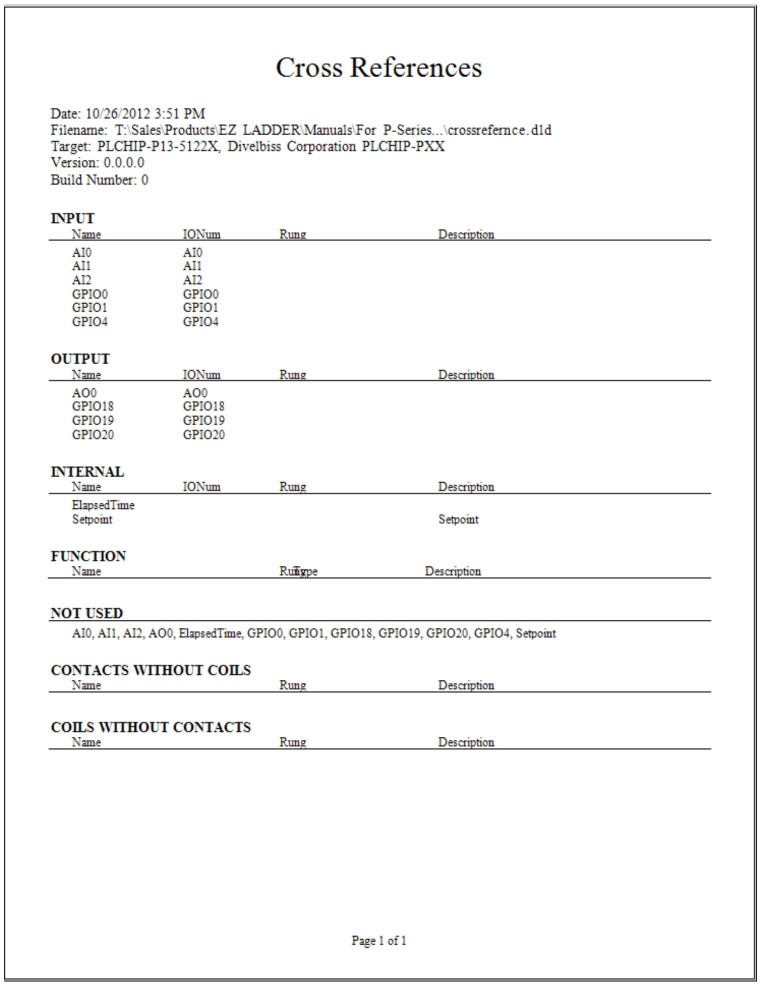
Using the check boxes provided, select or de-select the items desired to be included on the Cross Reference Report. The items to select are:

Input:	This will include all real world inputs on the report.
Output:	This will include all real world outputs on the report.
Internal:	This will include all *internal* contacts and coils on the report.
Function:	This will include all functions (function blocks) used on the report.
Unused Variables:	This will list any variables that are in the ladder diagram project, but are not actually used in the ladder diagram itself (created but not used).
Contact without Coil:	This will list all contacts that have been created and are used in the ladder diagram, but have no coil used in the ladder diagram,
Coil without Contact:	This will list all coils that have been created and are used in the ladder diagram, but have no contacts used in the ladder diagram.

Drum Sequencer Tables:	This will include all drum sequencer matrix tables on the report.
Retentive Variables:	This lists all variables (all types) that are configured to be retentive.
Network Address / Register:	This lists the variables and network addresses on the report (only variables with network addresses are listed).

For each option selected in the dialog box, the report is generated identifying the rung number, type and description for each item.

Click ok to generate the report. A report window will open displaying the generated report. Controls are provided to change pages and to print. Figure 20-3 represents the report that is viewed or printed.



Cross References

Date: 10/26/2012 3:51 PM
Filename: T:\Sales\Products\EZ LADDER\Manuals\For P-Series...\crossrefernce.dld
Target: PLCHIP-P13-5122X, Divelbiss Corporation PLCHIP-PXX
Version: 0.0.0.0
Build Number: 0

INPUT

Name	IONum	Rung	Description
AI0	AI0		
AI1	AI1		
AI2	AI2		
GPIO0	GPIO0		
GPIO1	GPIO1		
GPIO4	GPIO4		

OUTPUT

Name	IONum	Rung	Description
AO0	AO0		
GPIO18	GPIO18		
GPIO19	GPIO19		
GPIO20	GPIO20		

INTERNAL

Name	IONum	Rung	Description
ElapsedTime			
Setpoint			Setpoint

FUNCTION

Name	Rung Type	Description

NOT USED

AI0, AI1, AI2, AO0, ElapsedTime, GPIO0, GPIO1, GPIO18, GPIO19, GPIO20, GPIO4, Setpoint

CONTACTS WITHOUT COILS

Name	Rung	Description

COILS WITHOUT CONTACTS

Name	Rung	Description

Page 1 of 1

Figure 20-3

CHAPTER 22

Troubleshooting

This chapter provides basic information to understand how to solve problems and to identify problems and common error message found using the EZ LADDER Toolkit.

Chapter Contents

Error Messages

The following is a list of error messages that may be encountered when using the EZ LADDER Toolkit. While you may experience any of these messages, many are rarely encountered. These error message may appear as pop-up dialog boxes or in the Output window.

A different program is running (Monitor Mode)
When connecting to a target, the program running on the target is different than the program currently opened in EZ LADDER Toolkit.

Could not connect to target (Monitor Mode)
EZ LADDER Toolkit was not able to connect to a hardware target.

Could not get target version. Please connect first (Monitor Mode)
EZ LADDER Toolkit was unable to retrieve the target version when using the *target information* feature or button.

Could not open: COMX (Monitor Mode)
When connecting to a target, the selected Com Port does not exist or is in use. This is typically caused when another application is using and locked the serial port as a resource. Close the other application to correct this.

Error downloading file (Monitor Mode)
An unknown error occurred while downloading the program to target. Try downloading the program again.

ERROR downloading user program: invalid address (Monitor Mode)
An invalid address was detected in a communications packet while EZ LADDER Toolkit was connected to a target.

ERROR downloading user program: invalid record (Monitor Mode)
An invalid record was detected in a communications packet while EZ LADDER Toolkit was connected to a target.

ERROR downloading user program: checksum error (Monitor Mode)
An invalid checksum was detected in a communications packet while EZ LADDER Toolkit was connected to a target.

ERROR downloading user program: record to long (Monitor Mode)
An invalid record length was detected in a communications packet while EZ LADDER Toolkit was connected to a target.

ERROR putting target into bootloader (Monitor Mode)
An error occurred when EZ LADDER Toolkit was trying to access the target bootloader. Verify the serial connections and settings, cables and the target.

Error, serial port not open (Monitor Mode)
The serial port that is configured in EZ LADDER Toolkit cannot be opened for use. This may caused when another application is using and locked the serial port as a resource. Close the other application to correct this.

ERROR programming target (Monitor Mode)
EZ LADDER Toolkit detected an undefined error while attempting to store the project on the hardware target. Repeat the download (and store process) to correct this issue.

Error staring program. Program doesn't exist (Monitor Mode)
The program that is trying to start does not exist on the target. Download the program. This is typically caused by clicking the Go button before the ladder diagram project is loaded on the target.

Error starting program. Program could not be started (Monitor Mode)
The program cannot be started. Re-compile and download the program.

Error while receiving packet (Monitor Mode)
There was an error when receiving communications packets from the target.

File could not be opened (Monitor Mode)
When downloading the program to target, the file with the compiled code could not be opened. The file could have been moved or deleted. Compile the project and then download to the target.

Invalid File (Editor Mode)
The file you are trying to open in EZ LADDER Toolkit is not a valid EZ LADDER Toolkit ladder diagram file.

Invalid HEX file (Monitor Mode)
When downloading to a target, the file used to store compiled code is invalid, or corrupt. Re-compile the ladder diagram project to correct this issue.

x is not supported by the current target (Editor Mode)
The object or function block that you are trying to use and place is not supported on target selected in the Project Settings. This can be caused if the hardware target is changes after a ladder diagram is created, then function blocks are edited. Either change the target or delete this function block / object.

Ladder program is not present (Monitor Mode)
No ladder diagram program was detected on the connected hardware target.

Link at: (x, y) had an invalid Grid point (Editor Mode)
The link is open or not connected at a grid point. Correct or re-draw the link.

Link is not valid (Editor Mode)
The link you are trying to create is not valid. This is typically caused when trying to link one type of variable (integer, real, etc) to a function block or object that does not support that type or all variables linked to the function block must be identical types and you are trying to link a variable that does not match the types already connected to the function block.

No acknowledgement sent from target (x) (Monitor Mode)
The target did not send a no acknowledgement during communications with EZ LADDER Toolkit. This error can occur occasionally based on many factors. Click ok to clear.

Object already there (Editor Mode)
An object already exists where you are trying to place another object. Select a new location to place the object.

Object type: X, not found Aborting load (Editor Mode)
Error loading program into EZ LADDER Toolkit. The ladder diagram file may be corrupt.

Packet contained a formatting ERROR (Monitor Mode)
An packet formatting error was detected in a packet during communication with a target.

Packet contained an invalid checksum (Monitor Mode)
An invalid checksum was detected in a packet during communication with a target.

Packet length was invalid (Monitor Mode)
An invalid communications packet length was detected during communications with the connected target.

Please save project before compiling (Editor Mode)
EZ LADDER Toolkit projects must be saved prior to allowing them to be compiled. Save the ladder diagram project.

Please select a target (Editor Mode)
A target has not been selected. You must select and configure a target in the Project Settings before placing any objects and function blocks.

Please select a target before compiling (Editor Mode)
Unable to compile because no target was selected. You must select and configure a target in the Project Settings before compiling.

Please select a target before verifying (Editor Mode)
Unable to run program verification because no target is selected. You must select and configure a target in the Project Settings before verifying.

Targets do not match (Monitor Mode)
When connecting to a target the target specified in the ladder diagram project does not match the actual detected hardware target connected to the serial port. Correct the target in the Project Settings.

Target does not support bootloader (Monitor Mode)
This specific target is too old to support any bootloader functions. Contact Support for options.

There is not enough room for the paste. Increase the number of rungs (Editor Mode)
There is not enough rung space to paste from the clipboard. Increase the number of rungs where the paste is to occur.

There is not enough room to the right of the paste point. (Editor Mode)
There is not enough room at the insertion point to paste objects from the clipboard. Paste the objects farther left.

This object must be place in the last column (Editor Mode)

The selected object can only be placed in the last column. All coils can only be placed in the last column.

Timeout ERROR. Entire packet was not received (Monitor Mode)
During communication with a target, part of a packet was lost or not received.

Timeout ERROR. Target didn't respond (Monitor Mode)
During communication with a target, the target did not respond. Check the cables, connections, target and Serial port settings in EZ LADDER Toolkit.

Undefined packet type (Monitor Mode)
EZ Ladder has detected a undefined communications packet during communications with the connected target.

Structured Text Errors

The following is a list of structured text specific error messages that may be encountered when using the EZ LADDER Toolkit. These error message may appear as pop-up dialog boxes or in the Output window. For more details on structured text, refer to **Chapter 26 - Structured Text**.

Errors During Structured Text Verifying

The following is a list of structured text specific error messages that may be encountered when structured text is verified. Verification may be manually initiated in the Structured Text Editor. It is also performed automatically as a prerequisite during a ladder diagram Compile.

This error message gets formatted as {POU Name} {Location}: ERROR STV{Error Num}: {Description}

Member Name	Value	Description
Variable	1000	Generic variable error
Variable_NotDefined	1001	Variable is not defined message -> Variable {0} is not defined
Variable_NotModifiable	1002	Variable is not modifiable message ->
Variable_TypeMismatch	1003	Types don't match
Variable_NotArray	1004	Variable is not an array, don't use '[]' message -> Variable {0} is not an array
Variable_IsArray	1005	Variable is an array, make sure use '[]' message -> Variable {0} is an array, but subscript list is missing
Variable_ConstantNotInialized	1006	constant variable is not initialized message -> CONSTANT Variable {0} not initialized
Variable_ExternMustBeConstant	1007	Global Variable is defined as a constant, so external must be constant message -> Variable {0} is defined as CONSTANT
Variable_TooManyInit	1008	array has to many initializers message -> Variable {0} has too many initializers
Function	2000	Generic Function Error
Function_NotDefined	2001	Function is not defined message -> Function {0} is not defined
FunctionBlock	3000	Generic Function Block Error

Member Name	Value	Description
FunctionBlock_InstanceUndefined	3001	Function Block Instance is not defined message -> Function Block instance is undefined: {0}
FunctionBlock_NotSupportedHere	3002	Function Block is not supported here message -> Invalid expression, Function Block name {0} not supported here
TypeDeclarations	4000	Generic type definition errors
TypeDecl_NotDefined	4001	Type is not defined
EnumDeclarations	5000	Generic enumeration errors
EnumDecl_NotDefined	5001	Enumeration is not defined

Errors During Structured Text Code Generatrion

The following is a list of structured text specific error messages that may be encountered when structured text code is generated.

Member Name	Value	Description
Variable	1000	Generic Variable ERROR
Variable_NotDefined	1001	Variable is not defined message -> Variable {0} is not defined
Func_GenCode	2000	Generic code generation error, message -> Failed generating code for {0}
Func_GenCode_TooManyParams	2001	In function call user specified too many function parameters message -> Too many parameters for function call: {0}
Func_GenCode_TooLittleParams	2002	In function call user didn't specify enough function parameters message -> Too little parameters for function call: {0}
FuncBlk_GenCode	3000	

Common Ladder Diagram Errors

When creating ladder diagram projects using EZ LADDER Toolkit, here are some of the common errors made during the creating process.

Connecting Functions to Functions Errors

When connecting Variable outputs of one function to a variable input of another function, a variable must be placed between the two functions. Figure 22-1 illustrates the incorrect way of connecting functions to functions (variable inputs and outputs). Figure 22-2 illustrates the same ladder diagram project, but with the corrections made (a variable between the function blocks).

If a function's variable output is connected directly to another functions' variable input, the program will compile successfully, however; the program will not function as designed.
A variable must be placed between the output and the input for proper operation.

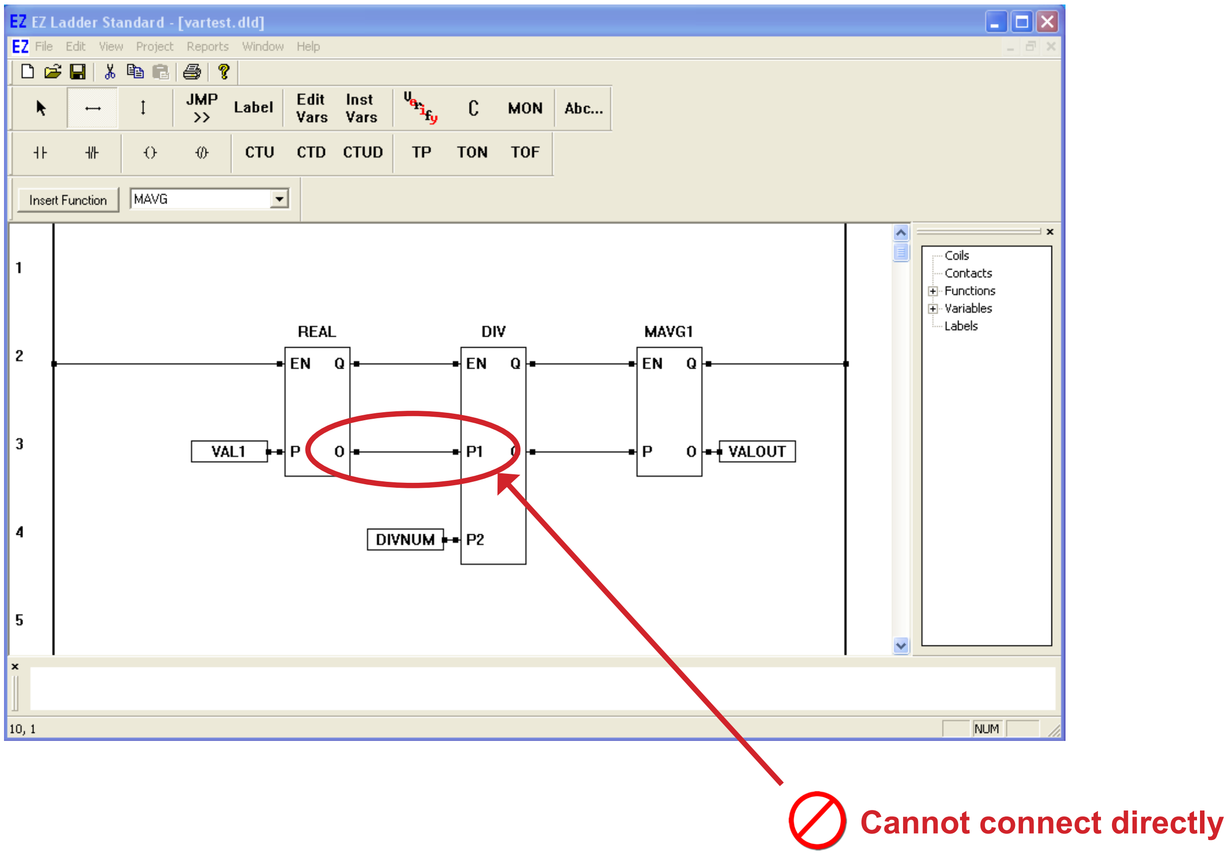


Figure 22-1

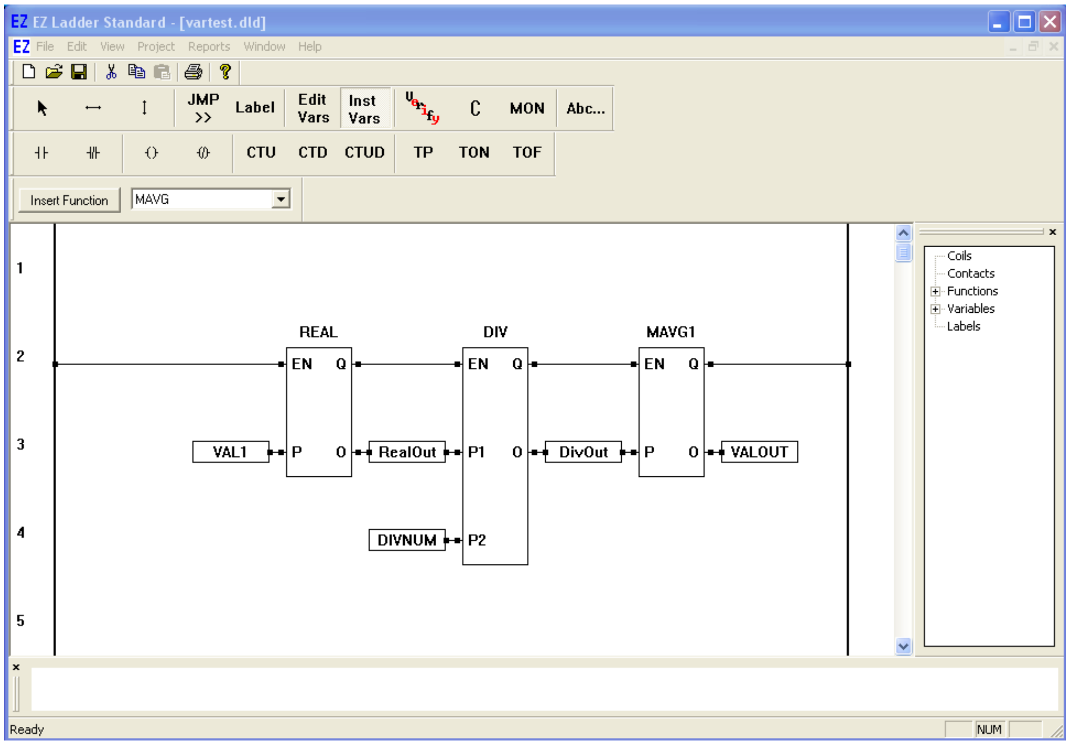


Figure 22-2

CHAPTER 23

Hardware Targets

This chapter provides detailed information for P-Series PLC on a Chip based hardware targets including supported functions and features for each as well as specific information needed to use hardware features.

Chapter Contents

P-Series PLC on a Chip™ Integrated Circuits

Each P-Series PLC on a Chip™ integrated circuit model supports different features and function blocks. Typically, the larger memory models support more features and function blocks. For all P-Series PLC on a Chip™ models, any feature listed must be individually installed using the Project Settings Menu.

PLCHIP-P13-5122X

All listed features and function blocks listed are supported individually. Using certain features or function blocks may limit the availability of other features and function blocks.

Features

On-Board Real Time Clock
Retentive Memory (using FM24xxx)
Up to 164 I/O Digital I/O
Up to 12 PWM Outputs
Quadrature Input
3 High Speed Counter / Timer Inputs
Up to 8 Analog Inputs, On-Board
Up to 1 Analog Output, On-Board
Up to 4 Serial Ports
Up to 2 CAN Ports
Ethernet Port
Up to 3 I^2C Ports
Up to 2 SPI Ports
EEPROM Storage (4000 bytes)
Modbus Master / Slave
Modbus TCP over Ethernet
OptiCAN Networking
J1939 / NMEA 2000 Networking
LCD Support
Keypad Support
Expandable Analog using SPI / I2C
SD Card Storage

Supported Function Blocks

Less Than (<)
Less Than Equal To (<=)
Not Equal To (<>)
Equal To (=)
Greater Than (>)
Greater Than Equal To (>=)
Absolute Value (ABS)
Arc Cosine (ACOS)
Addition (ADD)
Arc Sine (ASIN)
Arc Tangent (ATAN)
Bitwise AND (AND)
Average (AVG)
Bit Pack (BIT_PACK)
Bit Unpack (BIT_UNPACK)
Convert to Boolean (BOOLEAN)
Ceiling (CEIL)
Compare (CMP)
Cosine (COS)
Count Down (CTD)
Count Up (CTU)
Count Up / Down (CTUD)
Division (DIV)
Drum Sequencer (DRUM_SEQ)
EEprom Read (EEPROM_READ)
EEprom Write (EEPROM_Write)
Exponential (EXP)
Power Function (EXPT)
Falling Edge Detect (F_TRIG)
Floor (FLOOR)
Get Date (GETDATE)
Get Time (GETTIME
Hysteresis (HYSTER)
Convert to Integer (INTEGER)
J1939 Receive PGN (J1939_RX_PGN)
J1939 Transmit PGN (J1939_TX_PGN)
Jump (JMP)
Keypad (KEYPAD)
Keypad2 (KEYPAD2)
Label
Latching Coil (LATCH)
LCD Clear (LCD_CLEAR)
LCD Print (LCD_PRINT)
Limit (LIMIT)
LS7366R Quad Counter (CNTR_LS7366R)
Natural Logarithm (LN)
Base-10 Logarithm (LOG)
Modbus Master (MODBUS_MASTER)
Moving Average (MAVG)
Maximum (MAX)
Minimum (MIN)
Modulo (MOD)
Multiplication (MULT)
Multiplexer (MUX)
Bitwise NOT (NOT)
Optican Node Status (OPTICAN_NODESTATUS)

Optican Transmit Message (OPTICAN_TXNETMSG)
Bitwise OR (OR)
PID (PID)
PLCHIP Quad Counter (CNTR_PXX_QEI)
PLCHIP Quad Counter Compare (CNTR_PXX_CMP)
PLCHIP Quad Counter Velocity (CNTR_PXX_VEL)
PWM (PWM)
PWM Frequency (PWM_FREQ)
Rising Edge Detect (R_TRIG)
Random (RANDOM)
Convert to Real (REAL)
Rotate Left (ROL)
Rotate Right (ROR)
Reset / Set -Reset Dominant (RS)
Seed Random (SEED)
Select (SEL)
Serial Print (SERIAL_PRINT)
Set Date (SETDATE)
Set Time (SETTIME)
Shift Left (SHL)
Shift Right (SHR)
Sine (SIN)
Square Root (SQRT)
Set / Reset -Set Dominant (SR)
Structured Text Function (ST_FUNC)
Structured Text Function Block (ST_FUNC_BLK)
Subtraction (SUB)
Tangent (TAN)
Convert to Timer (TIMER)
Time Delay Off (TOF)
Time Delay On (TON)
Timer Counter (TimerCounter)
Pulse Timer (TP)
Uart Set Property (UART_SET_PROPERTY)
Unlatching Coil (UNLATCH)
Bitwise XOR (XOR)

HEC-P5xxx Series

Each HEC-P5xxx model supports different features and function blocks based differences in the internal hardware. When any HEC-P5xxx model is selected in the Project Settings, some supported functions are automtically installed while others must be manually installed.

HEC-P5000

Features

On-Board Real Time Clock
Retentive Memory (FRAM 480 bytes)
16 Digital Inputs - Sink / Source (DC)
12 PWM / On, Off Digital Outputs (DC)
4 On,Off Digital Outputs (DC)
Quadrature Input
3 High Speed Counter / Timer Inputs - NPN/PNP
SD Card Support
2 Analog Inputs, Range/Type Field Adjustable
2 Serial Ports RS232/RS485
2 CAN Ports
Ethernet Port
EEPROM Storage (4000 bytes)
Modbus Master / Slave
Modbus TCP over Ethernet
OptiCAN Networking
J1939 / NMEA 2000 Networking

Supported Function Blocks

Less Than (<)
Less Than Equal To (<=)
Not Equal To (<>)
Equal To (=)
Greater Than (>)
Greater Than Equal To (>=)
Absolute Value (ABS)
Arc Cosine (ACOS)
Addition (ADD)
Arc Sine (ASIN)
Arc Tangent (ATAN)
Bitwise AND (AND)
Average (AVG)
Bit Pack (BIT_PACK)
Bit Unpack (BIT_UNPACK)
Convert to Boolean (BOOLEAN)
Compare (CMP)
Cosine (COS)
Count Down (CTD)
Count Up (CTU)
Count Up / Down (CTUD)
Division (DIV)
Drum Sequencer (DRUM_SEQ)
EEprom Read (EEPROM_READ)
EEprom Write (EEPROM_Write)
Exponential (EXP)
Power Function (EXPT)
Falling Edge Detect (F_TRIG)
Floor (FLOOR)
Get Date (GETDATE)
Get Time (GETTIME
Hysteresis (HYSTER)
Convert to Integer (INTEGER)
J1939 Receive PGN (J1939_RX_PGN)
J1939 Transmit PGN (J1939_TX_PGN)
Jump (JMP)
Label
Latching Coil (LATCH)
Limit (LIMIT)
Natural Logarithm (LN)
Base-10 Logarithm (LOG)
Modbus Master (MODBUS_MASTER)
Moving Average (MAVG)
Maximum (MAX)
Minimum (MIN)
Modulo (MOD)
Multiplication (MULT)
Multiplexer (MUX)
Bitwise NOT (NOT)
Optican Node Status (OPTICAN_NODESTATUS)
Optican Transmit Message (OPTICAN_TXNETMSG)
Bitwise OR (OR)
PID (PID)
PLCHIP Quad Counter (CNTR_PXX_QEI)
PLCHIP Quad Counter Compare (CNTR_PXX_CMP)
PLCHIP Quad Counter Velocity (CNTR_PXX_VEL)
PWM (PWM)
PWM Frequency (PWM_FREQ)
Rising Edge Detect (R_TRIG)
Random (RANDOM)
Convert to Real (REAL)
Rotate Left (ROL)
Rotate Right (ROR)
Reset / Set -Reset Dominant (RS)
Seed Random (SEED)
Select (SEL)
Serial Print (SERIAL_PRINT)
Set Date (SETDATE)

Set Time (SETTIME)
Shift Left (SHL)
Shift Right (SHR)
Sine (SIN)
Square Root (SQRT)
Set / Reset -Set Dominant (SR)
Structured Text Function (ST_FUNC)
Structured Text Function Block (ST_FUNC_BLK)
Subtraction (SUB)
Tangent (TAN)
Convert to Timer (TIMER)
Time Delay Off (TOF)
Time Delay On (TON)
Timer Counter (TimerCounter)
Pulse Timer (TP)
Uart Set Property (UART_SET_PROPERTY)
Unlatching Coil (UNLATCH)
Bitwise XOR (XOR)

HEC-P5100

Features

Retentive Memory (FRAM 480 bytes)
16 Digital Inputs - Sink / Source (DC)
12 PWM / On, Off Digital Outputs (DC)
4 On,Off Digital Outputs (DC)
Quadrature Input
3 High Speed Counter / Timer Inputs - NPN/PNP
SD Card Support
2 Analog Inputs, Range/Type Field Adjustable
2 CAN Ports
EEPROM Storage (4000 bytes)
Modbus Master / Slave
OptiCAN Networking
J1939 / NMEA 2000 Networking

Supported Function Blocks

Less Than (<)
Less Than Equal To (<=)
Not Equal To (<>)
Equal To (=)
Greater Than (>)
Greater Than Equal To (>=)
Absolute Value (ABS)
Arc Cosine (ACOS)
Addition (ADD)
Arc Sine (ASIN)
Arc Tangent (ATAN)
Bitwise AND (AND)
Average (AVG)
Bit Pack (BIT_PACK)
Bit Unpack (BIT_UNPACK)
Convert to Boolean (BOOLEAN)
Compare (CMP)
Cosine (COS)
Count Down (CTD)
Count Up (CTU)
Count Up / Down (CTUD)
Division (DIV)
Drum Sequencer (DRUM_SEQ)
EEprom Read (EEPROM_READ)
EEprom Write (EEPROM_Write)
Exponential (EXP)
Power Function (EXPT)
Falling Edge Detect (F_TRIG)
Floor (FLOOR)
Get Date (GETDATE)
Get Time (GETTIME
Hysteresis (HYSTER)
Convert to Integer (INTEGER)
J1939 Receive PGN (J1939_RX_PGN)
J1939 Transmit PGN (J1939_TX_PGN)
Jump (JMP)
Label
Latching Coil (LATCH)
Limit (LIMIT)
Natural Logarithm (LN)
Base-10 Logarithm (LOG)
Modbus Master (MODBUS_MASTER)
Moving Average (MAVG)
Maximum (MAX)
Minimum (MIN)
Modulo (MOD)
Multiplication (MULT)
Multiplexer (MUX)
Bitwise NOT (NOT)
Optican Node Status (OPTICAN_NODESTATUS)
Optican Transmit Message (OPTICAN_TXNETMSG)
Bitwise OR (OR)
PID (PID)
PLCHIP Quad Counter (CNTR_PXX_QEI)
PLCHIP Quad Counter Compare (CNTR_PXX_CMP)
PLCHIP Quad Counter Velocity (CNTR_PXX_VEL)
PWM (PWM)
PWM Frequency (PWM_FREQ)
Rising Edge Detect (R_TRIG)
Random (RANDOM)
Convert to Real (REAL)
Rotate Left (ROL)
Rotate Right (ROR)
Reset / Set -Reset Dominant (RS)
Seed Random (SEED)
Select (SEL)
Serial Print (SERIAL_PRINT)
Set Date (SETDATE)
Set Time (SETTIME)
Shift Left (SHL)
Shift Right (SHR)
Sine (SIN)
Square Root (SQRT)
Set / Reset -Set Dominant (SR)
Structured Text Function (ST_FUNC)
Structured Text Function Block (ST_FUNC_BLK)
Subtraction (SUB)
Tangent (TAN)
Convert to Timer (TIMER)
Time Delay Off (TOF)
Time Delay On (TON)
Timer Counter (TimerCounter)
Pulse Timer (TP)
Uart Set Property (UART_SET_PROPERTY)
Unlatching Coil (UNLATCH)
Bitwise XOR (XOR)

VB-2xxx Series

Each VB-2XXX model supports different features and function blocks based differences of the on-board hardware. When any VB-2XXX model is selected in the Project Settings, some supported functions are automtically installed while others must be manually installed.

VB-2000

Features

Retentive Memory (FRAM 480 bytes)
12 Digital Inputs - Sink / Source (DC)
8 PWM / On, Off Digital Outputs (DC)
3 High Speed Counter / Timer Inputs - NPN/PNP
SD Card Support
7 Analog Inputs, Range/Type Field Adjustable
1 Analog Output, Range/type Field Adjustable
2 Serial Ports RS232/RS485
1 CAN Port
EEPROM Storage (4000 bytes)
Modbus Master / Slave
OptiCAN Networking
J1939 / NMEA 2000 Networking
VBDSP-X Display Port
Keypad Port
Din Rail Mount
EXP Plug-in Expansion Port

Supported Function Blocks

Less Than (<)
Less Than Equal To (<=)
Not Equal To (<>)
Equal To (=)
Greater Than (>)
Greater Than Equal To (>=)
Absolute Value (ABS)
Arc Cosine (ACOS)
Addition (ADD)
Arc Sine (ASIN)
Arc Tangent (ATAN)
Bitwise AND (AND)
Average (AVG)
Bit Pack (BIT_PACK)
Bit Unpack (BIT_UNPACK)
Convert to Boolean (BOOLEAN)
Compare (CMP)
Cosine (COS)
Count Down (CTD)
Count Up (CTU)
Count Up / Down (CTUD)
Division (DIV)
Drum Sequencer (DRUM_SEQ)
EEprom Read (EEPROM_READ)
EEprom Write (EEPROM_Write)
Exponential (EXP)
Power Function (EXPT)
Falling Edge Detect (F_TRIG)
Floor (FLOOR)
Hysteresis (HYSTER)
Convert to Integer (INTEGER)
J1939 Receive PGN (J1939_RX_PGN)
J1939 Transmit PGN (J1939_TX_PGN)
Jump (JMP)
Keypad
Keypad2
Label
Latching Coil (LATCH)
LCD Print
LCD Clear
Limit (LIMIT)
Natural Logarithm (LN)
Base-10 Logarithm (LOG)
Modbus Master (MODBUS_MASTER)
Moving Average (MAVG)
Maximum (MAX)
Minimum (MIN)
Modulo (MOD)
Multiplication (MULT)
Multiplexer (MUX)
Bitwise NOT (NOT)
Optican Node Status (OPTICAN_NODESTATUS)
Optican Transmit Message (OPTICAN_TXNETMSG)
Bitwise OR (OR)
PID (PID)
PWM (PWM)
PWM Frequency (PWM_FREQ)
Rising Edge Detect (R_TRIG)
Random (RANDOM)
Convert to Real (REAL)
Rotate Left (ROL)
Rotate Right (ROR)
Reset / Set -Reset Dominant (RS)
Seed Random (SEED)
Select (SEL)
Serial Print (SERIAL_PRINT)
Set Date (SETDATE)
Set Time (SETTIME)
Shift Left (SHL)
Shift Right (SHR)

Sine (SIN)
Square Root (SQRT)
Set / Reset -Set Dominant (SR)
Structured Text Function (ST_FUNC)
Structured Text Function Block (ST_FUNC_BLK)
Subtraction (SUB)
Tangent (TAN)
Convert to Timer (TIMER)
Time Delay Off (TOF)
Time Delay On (TON)
Timer Counter (TimerCounter)
Pulse Timer (TP)
Uart Set Property (UART_SET_PROPERTY)
Unlatching Coil (UNLATCH)
Bitwise XOR (XOR)

VB-2100

Features

On-Board Real Time Clock
Retentive Memory (FRAM 480 bytes)
12 Digital Inputs - Sink / Source (DC)
8 PWM / On, Off Digital Outputs (DC)
3 High Speed Counter / Timer Inputs - NPN/PNP
SD Card Support
7 Analog Inputs, Range/Type Field Adjustable
1 Analog Output, Range/type Field Adjustable
2 Serial Ports RS232/RS485
1 CAN Port
Ethernet Port
EEPROM Storage (4000 bytes)
Modbus Master / Slave
Modbus TCP over Ethernet
OptiCAN Networking
J1939 / NMEA 2000 Networking
VBDSP-X Display Port
Keypad Port
Din Rail Mount
EXP Plug-in Expansion Port

Supported Function Blocks

Less Than (<)
Less Than Equal To (<=)
Not Equal To (<>)
Equal To (=)
Greater Than (>)
Greater Than Equal To (>=)
Absolute Value (ABS)
Arc Cosine (ACOS)
Addition (ADD)
Arc Sine (ASIN)
Arc Tangent (ATAN)
Bitwise AND (AND)
Average (AVG)
Bit Pack (BIT_PACK)
Bit Unpack (BIT_UNPACK)
Convert to Boolean (BOOLEAN)
Compare (CMP)
Cosine (COS)
Count Down (CTD)
Count Up (CTU)
Count Up / Down (CTUD)
Division (DIV)
Drum Sequencer (DRUM_SEQ)
EEprom Read (EEPROM_READ)
EEprom Write (EEPROM_Write)
Exponential (EXP)
Power Function (EXPT)
Falling Edge Detect (F_TRIG)
Floor (FLOOR)
Get Date (GETDATE)
Get Time (GETTIME
Hysteresis (HYSTER)
Convert to Integer (INTEGER)
J1939 Receive PGN (J1939_RX_PGN)
J1939 Transmit PGN (J1939_TX_PGN)
Jump (JMP)
Keypad
Keypad2
Label
Latching Coil (LATCH)
LCD Display
LCD Clear
Limit (LIMIT)
Natural Logarithm (LN)
Base-10 Logarithm (LOG)
Modbus Master (MODBUS_MASTER)
Moving Average (MAVG)
Maximum (MAX)
Minimum (MIN)
Modulo (MOD)
Multiplication (MULT)
Multiplexer (MUX)

Bitwise NOT (NOT)
Optican Node Status (OPTICAN_NODESTATUS)
Optican Transmit Message (OPTICAN_TXNETMSG)
Bitwise OR (OR)
PID (PID)
PWM (PWM)
PWM Frequency (PWM_FREQ)
Rising Edge Detect (R_TRIG)
Random (RANDOM)
Convert to Real (REAL)
Rotate Left (ROL)
Rotate Right (ROR)
Reset / Set -Reset Dominant (RS)
Seed Random (SEED)
Select (SEL)
Serial Print (SERIAL_PRINT)
Set Date (SETDATE)
Set Time (SETTIME)
Shift Left (SHL)
Shift Right (SHR)
Sine (SIN)
Square Root (SQRT)
Set / Reset -Set Dominant (SR)
Structured Text Function (ST_FUNC)
Structured Text Function Block (ST_FUNC_BLK)
Subtraction (SUB)
Tangent (TAN)
Convert to Timer (TIMER)
Time Delay Off (TOF)
Time Delay On (TON)
Timer Counter (TimerCounter)
Pulse Timer (TP)
Uart Set Property (UART_SET_PROPERTY)
Unlatching Coil (UNLATCH)
Bitwise XOR (XOR)

VB-2200

Features

On-Board Real Time Clock
Retentive Memory (FRAM 480 bytes)
12 Digital Inputs - Sink / Source (DC)
8 PWM / On, Off Digital Outputs (DC)
3 High Speed Counter / Timer Inputs - NPN/PNP
SD Card Support
7 Analog Inputs, Range/Type Field Adjustable
1 Analog Output, Range/type Field Adjustable
2 Serial Ports RS232/RS485
1 CAN Port
Ethernet Port
EEPROM Storage (4000 bytes)
Modbus Master / Slave
Modbus TCP over Ethernet
OptiCAN Networking
J1939 / NMEA 2000 Networking
Standard LCD Display Port
Keypad Port
Din Rail Mount
EXP Plug-in Expansion Port

Supported Function Blocks

Less Than (<)
Less Than Equal To (<=)
Not Equal To (<>)
Equal To (=)
Greater Than (>)
Greater Than Equal To (>=)
Absolute Value (ABS)
Arc Cosine (ACOS)
Addition (ADD)
Arc Sine (ASIN)
Arc Tangent (ATAN)
Bitwise AND (AND)
Average (AVG)
Bit Pack (BIT_PACK)
Bit Unpack (BIT_UNPACK)
Convert to Boolean (BOOLEAN)
Compare (CMP)
Cosine (COS)
Count Down (CTD)
Count Up (CTU)
Count Up / Down (CTUD)
Division (DIV)
Drum Sequencer (DRUM_SEQ)
EEprom Read (EEPROM_READ)

EEprom Write (EEPROM_Write)
Exponential (EXP)
Power Function (EXPT)
Falling Edge Detect (F_TRIG)
Floor (FLOOR)
Get Date (GETDATE)
Get Time (GETTIME
Hysteresis (HYSTER)
Convert to Integer (INTEGER)
J1939 Receive PGN (J1939_RX_PGN)
J1939 Transmit PGN (J1939_TX_PGN)
Jump (JMP)
Keypad
Keypad2
Label
Latching Coil (LATCH)
LCD Display
LCD Clear
Limit (LIMIT)
Natural Logarithm (LN)
Base-10 Logarithm (LOG)
Modbus Master (MODBUS_MASTER)
Moving Average (MAVG)
Maximum (MAX)
Minimum (MIN)
Modulo (MOD)
Multiplication (MULT)
Multiplexer (MUX)
Bitwise NOT (NOT)
Optican Node Status (OPTICAN_NODESTATUS)
Optican Transmit Message (OPTICAN_TXNETMSG)
Bitwise OR (OR)
PID (PID)
PWM (PWM)
PWM Frequency (PWM_FREQ)
Rising Edge Detect (R_TRIG)
Random (RANDOM)
Convert to Real (REAL)
Rotate Left (ROL)
Rotate Right (ROR)
Reset / Set -Reset Dominant (RS)
Seed Random (SEED)
Select (SEL)
Serial Print (SERIAL_PRINT)
Set Date (SETDATE)
Set Time (SETTIME)
Shift Left (SHL)
Shift Right (SHR)
Sine (SIN)
Square Root (SQRT)
Set / Reset -Set Dominant (SR)
Structured Text Function (ST_FUNC)
Structured Text Function Block (ST_FUNC_BLK)
Subtraction (SUB)
Tangent (TAN)
Convert to Timer (TIMER)
Time Delay Off (TOF)
Time Delay On (TON)
Timer Counter (TimerCounter)
Pulse Timer (TP)
Uart Set Property (UART_SET_PROPERTY)
Unlatching Coil (UNLATCH)
Bitwise XOR (XOR)

P-Series Bear Bones Controllers

Each P-Series Bear Bones controller model supports different features and function blocks based differences of the on-board hardware. When any P-Series Bear Bones model is selected in the Project Settings, some supported functions are automtically installed while others must be manually installed.

ICM-BB-P13-30

Features

On-Board Real Time Clock
Retentive Memory (FRAM 480 bytes)
8 Digital Inputs - Sink / Source (DC)
8 On, Off Digital Outputs (DC)
SD Card Support
Up to 8 Analog Inputs, Range/Type Field Adjustable
Up to 1 Analog Output, Range Field Adjustable
1 CAN Port
Ethernet Port
EEPROM Storage (4000 bytes)
Modbus TCP over Ethernet
OptiCAN Networking
J1939 / NMEA 2000 Networking
Standard LCD Display Port
Keypad Port
EXP1 / EXP2Plug-in Expansion Ports
Expandable I/O
Accepts ICM-PUI-01 Expander

Supported Function Blocks

Less Than (<)
Less Than Equal To (<=)
Not Equal To (<>)
Equal To (=)
Greater Than (>)
Greater Than Equal To (>=)
Absolute Value (ABS)
Arc Cosine (ACOS)
Addition (ADD)
Arc Sine (ASIN)
Arc Tangent (ATAN)
Bitwise AND (AND)
Average (AVG)
Bit Pack (BIT_PACK)
Bit Unpack (BIT_UNPACK)
Convert to Boolean (BOOLEAN)
Compare (CMP)
Cosine (COS)
Count Down (CTD)
Count Up (CTU)
Count Up / Down (CTUD)
Division (DIV)
Drum Sequencer (DRUM_SEQ)
EEprom Read (EEPROM_READ)
EEprom Write (EEPROM_Write)
Exponential (EXP)
Power Function (EXPT)
Falling Edge Detect (F_TRIG)
Floor (FLOOR)
Get Date (GETDATE)
Get Time (GETTIME
Hysteresis (HYSTER)
Convert to Integer (INTEGER)
J1939 Receive PGN (J1939_RX_PGN)
J1939 Transmit PGN (J1939_TX_PGN)
Jump (JMP)
Keypad
Keypad2
Label
Latching Coil (LATCH)
LCD Display
LCD Clear
Limit (LIMIT)
Natural Logarithm (LN)
Base-10 Logarithm (LOG)
Modbus Master (MODBUS_MASTER)
Moving Average (MAVG)
Maximum (MAX)
Minimum (MIN)
Modulo (MOD)
Multiplication (MULT)
Multiplexer (MUX)
Bitwise NOT (NOT)
Optican Node Status (OPTICAN_NODESTATUS)
Optican Transmit Message (OPTICAN_TXNETMSG)
Bitwise OR (OR)
PID (PID)
Rising Edge Detect (R_TRIG)
Random (RANDOM)
Convert to Real (REAL)
Rotate Left (ROL)
Rotate Right (ROR)
Reset / Set -Reset Dominant (RS)
Seed Random (SEED)
Select (SEL)
Set Date (SETDATE)
Set Time (SETTIME)
Shift Left (SHL)
Shift Right (SHR)
Sine (SIN)

Square Root (SQRT)
Set / Reset -Set Dominant (SR)
Structured Text Function (ST_FUNC)
Structured Text Function Block (ST_FUNC_BLK)
Subtraction (SUB)
Tangent (TAN)
Convert to Timer (TIMER)
Time Delay Off (TOF)
Time Delay On (TON)
Timer Counter (TimerCounter)
Pulse Timer (TP)
Uart Set Property (UART_SET_PROPERTY)
Unlatching Coil (UNLATCH)
Bitwise XOR (XOR)

ICM-BB-P13-40

Features

On-Board Real Time Clock
Retentive Memory (FRAM 480 bytes)
8 Digital Inputs - Sink / Source (120VAC)
8 On, Off Digital Outputs (120VAC)
SD Card Support
Up to 8 Analog Inputs, Range/Type Field Adjustable
Up to 1 Analog Output, Range Field Adjustable
1 CAN Port
Ethernet Port
EEPROM Storage (4000 bytes)
Modbus TCP over Ethernet
OptiCAN Networking
J1939 / NMEA 2000 Networking
Standard LCD Display Port
Keypad Port
EXP1 / EXP2Plug-in Expansion Ports
Expandable I/O
Accepts ICM-PUI-01 Expander

Supported Function Blocks

Less Than (<)
Less Than Equal To (<=)
Not Equal To (<>)
Equal To (=)
Greater Than (>)
Greater Than Equal To (>=)
Absolute Value (ABS)
Arc Cosine (ACOS)
Addition (ADD)
Arc Sine (ASIN)
Arc Tangent (ATAN)
Bitwise AND (AND)
Average (AVG)
Bit Pack (BIT_PACK)
Bit Unpack (BIT_UNPACK)
Convert to Boolean (BOOLEAN)
Compare (CMP)
Cosine (COS)
Count Down (CTD)
Count Up (CTU)
Count Up / Down (CTUD)
Division (DIV)
Drum Sequencer (DRUM_SEQ)
EEprom Read (EEPROM_READ)
EEprom Write (EEPROM_Write)
Exponential (EXP)
Power Function (EXPT)
Falling Edge Detect (F_TRIG)
Floor (FLOOR)
Get Date (GETDATE)
Get Time (GETTIME
Hysteresis (HYSTER)
Convert to Integer (INTEGER)
J1939 Receive PGN (J1939_RX_PGN)
J1939 Transmit PGN (J1939_TX_PGN)
Jump (JMP)
Keypad
Keypad2
Label
Latching Coil (LATCH)
LCD Display
LCD Clear
Limit (LIMIT)
Natural Logarithm (LN)
Base-10 Logarithm (LOG)
Modbus Master (MODBUS_MASTER)
Moving Average (MAVG)
Maximum (MAX)
Minimum (MIN)
Modulo (MOD)
Multiplication (MULT)
Multiplexer (MUX)
Bitwise NOT (NOT)
Optican Node Status (OPTICAN_NODESTATUS)
Optican Transmit Message (OPTICAN_TXNETMSG)
Bitwise OR (OR)
PID (PID)
Rising Edge Detect (R_TRIG)
Random (RANDOM)
Convert to Real (REAL)

Rotate Left (ROL)
Rotate Right (ROR)
Reset / Set -Reset Dominant (RS)
Seed Random (SEED)
Select (SEL)
Set Date (SETDATE)
Set Time (SETTIME)
Shift Left (SHL)
Shift Right (SHR)
Sine (SIN)
Square Root (SQRT)
Set / Reset -Set Dominant (SR)
Structured Text Function (ST_FUNC)
Structured Text Function Block (ST_FUNC_BLK)
Subtraction (SUB)
Tangent (TAN)
Convert to Timer (TIMER)
Time Delay Off (TOF)
Time Delay On (TON)
Timer Counter (TimerCounter)
Pulse Timer (TP)
Uart Set Property (UART_SET_PROPERTY)
Unlatching Coil (UNLATCH)
Bitwise XOR (XOR)

CHAPTER 24

Function Reference

This chapter provides detailed information for each function block and object found in the EZ LADDER Toolkit (for P-Series Targets). For each function block and object, the following is provided: type, inputs, outputs and other special instructions needed to use them.

Chapter Contents

Object and Function Block Basics

This chapter provides information on using each of the EZ LADDER Toolkit function blocks and objects. For each object or function, the symbol diagram, information on the inputs and outputs and a description of the function or block operation is provided. When applicable, truth tables, timing diagrams or other functions details are provided.

This information is to provide basic practices of how each function or object works and is not intended to provide complete applications or uses.

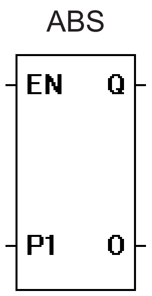
As this chapter is a reference, providing function block and object details on ALL functions available EZ LADDER Toolkit, the presence of a function does not guarantee availability of the function on all hardware targets.

Availability of functions and objects is determined by the hardware target that is configured for the ladder diagram projects. Some functions and objects are not available on some targets. Refer to the actual hardware target's data sheet / manual or **Chapter 22 - Hardware Targets** for a list of supported functions and objects based on target selection.

It is important to formulate which function blocks may be used in a ladder diagram project and then verify and select the target that supports the desired features and function blocks.

All objects and function blocks described in this chapter are organized in alphabetical order.

ABS



Description:

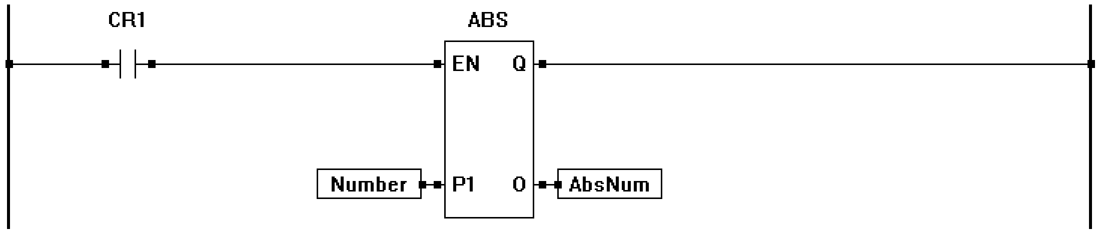
The ABS function provides an absolute value output (O) from the input value (P1). The enable (EN) must be true for the ABS function block to be enabled. The Q output is true when the ABS function is enabled.

Input / Output Connections:

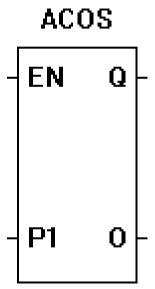
The ABS function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X	X				
Q	Output			X			
O	Output	X	X				

Example Circuit:



ACOS



Description:

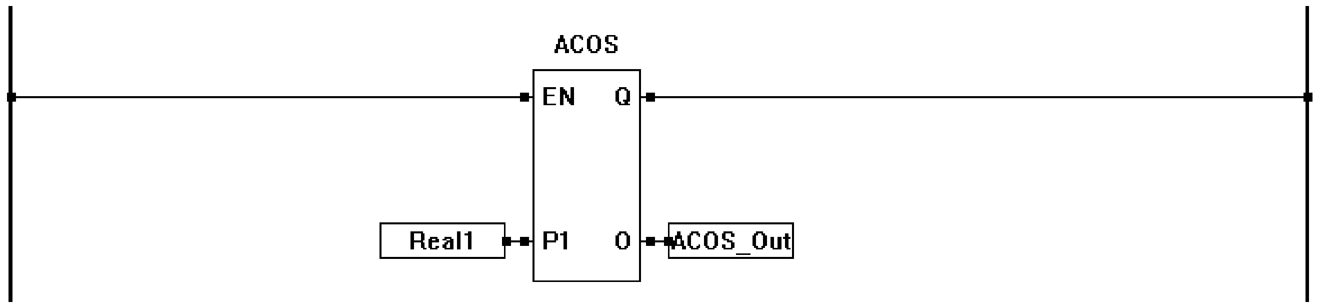
The ACOS function provides an Arc cosine (O) from the input value (P1). The enable (EN) must be true for the ACOS function to be enabled. The Q output is true when the ACOS function is enabled.

Input / Output Connections:

The ACOS function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

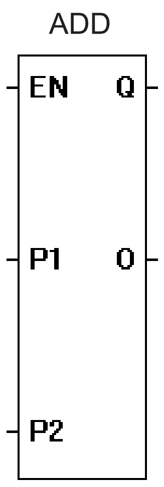
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Arc Cosine of P1 Base Number

Example Circuit:



Related Functions: ASIN, ATAN, COS, SIN, TAN

ADD



Description:

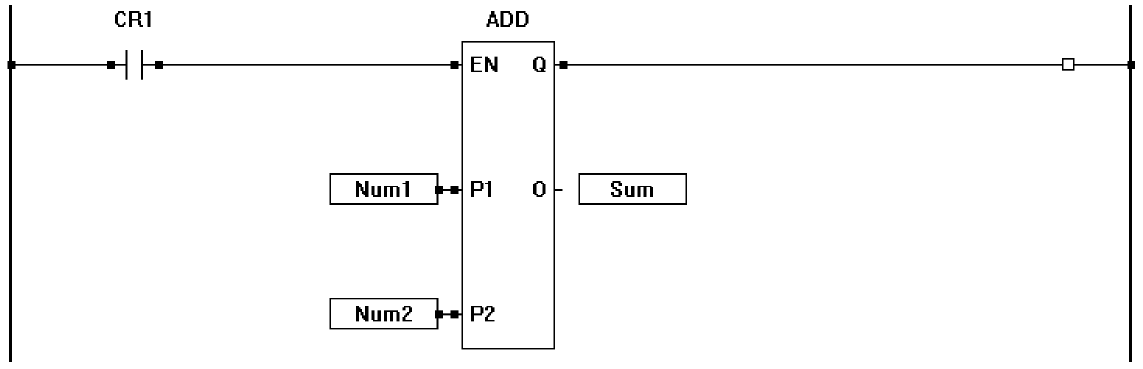
The ADD functions sums all the inputs (Px) together and outputs this number (O). The number of inputs is specified when the function is placed in the program. The enable (EN) must be true for the ADD function to be enabled. The Q output is true when the ADD function is enabled.

Input / Output Connections:

The ADD function block placement requires connections of at least three input pins (EN, P1, P2) and two output pins (Q, O).The number of inputs is specified when the function is inserted. The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

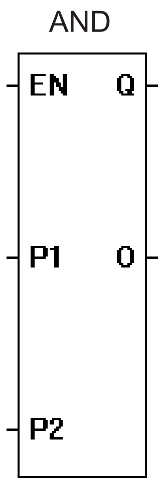
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
Px	Input	X	X				Number of inputs is dynamic
Q	Output			X			
O	Output	X	X				

Example Circuit:



Related Functions: SUB, MULT, DIV

AND



Description:

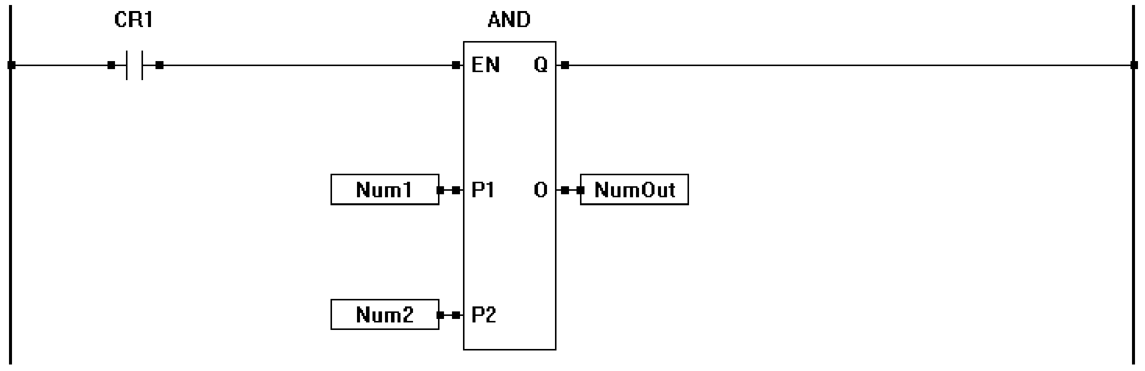
The AND functions provides a bitwise AND function of the P1 and P2 inputs. The enable (EN) must be true for the AND function to be enabled. The Q output is true when the AND function is enabled.

Input / Output Connections:

The AND function block placement requires connections of three input pins (EN, P1, P2) and two output pins (Q, O).

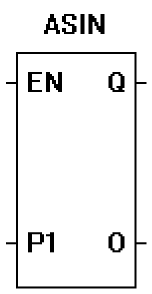
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X					
P2	Input	X					
Q	Output			X			
O	Output	X					

Example Circuit:



Related Functions: OR, NOT, XOR

ASIN



Description:

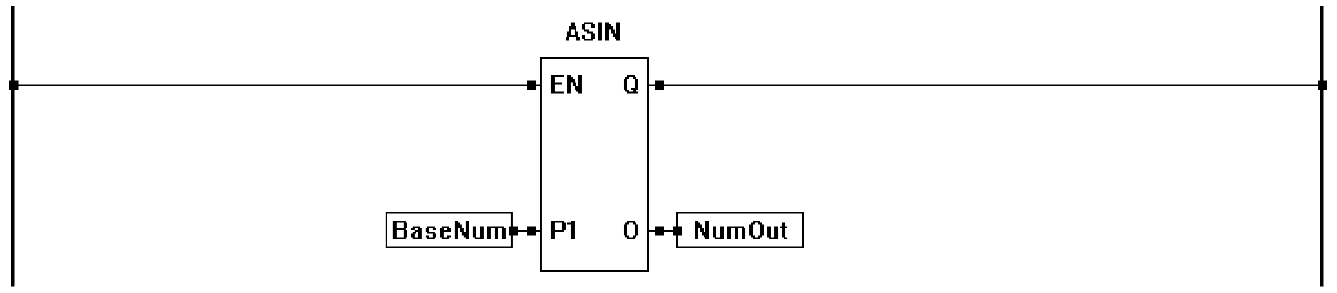
The ASIN function provides an Arcsine (O) from the input value (P1). The enable (EN) must be true for the ASIN function to be enabled. The Q output is true when the ASIN function is enabled.

Input / Output Connections:

The ASIN function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

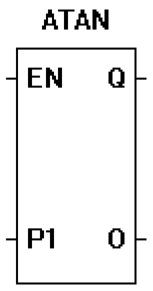
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Arc Sine of P1 Base Number

Example Circuit:



Related Functions: ACOS, ATAN, COS, SIN, TAN

ATAN



Description:

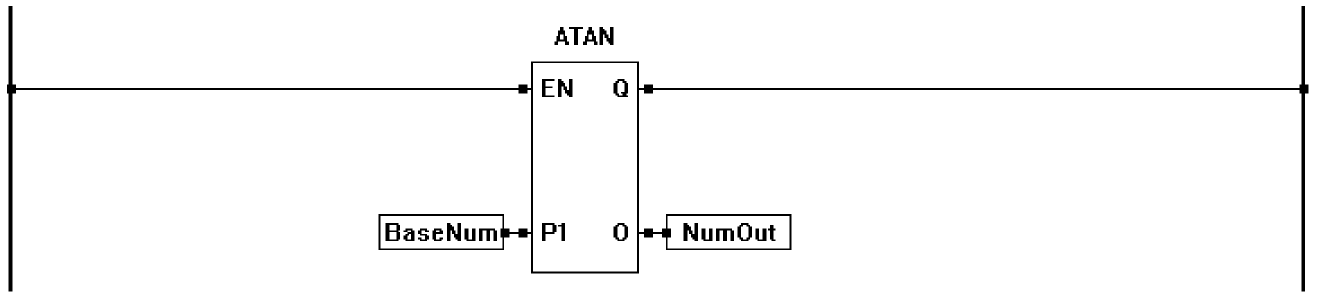
The ATAN function provides an Arctangent (O) from the input value (P1). The enable (EN) must be true for the ATAN function to be enabled. The Q output is true when the ATAN function is enabled.

Input / Output Connections:

The ATAN function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

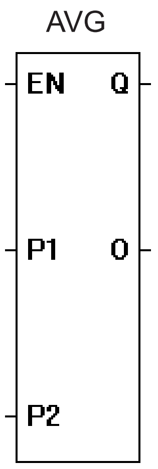
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Arc Tangent of P1 Base Number

Example Circuit:



Related Functions: ACOS, ASIN, COS, SIN, TAN

AVG



Description:

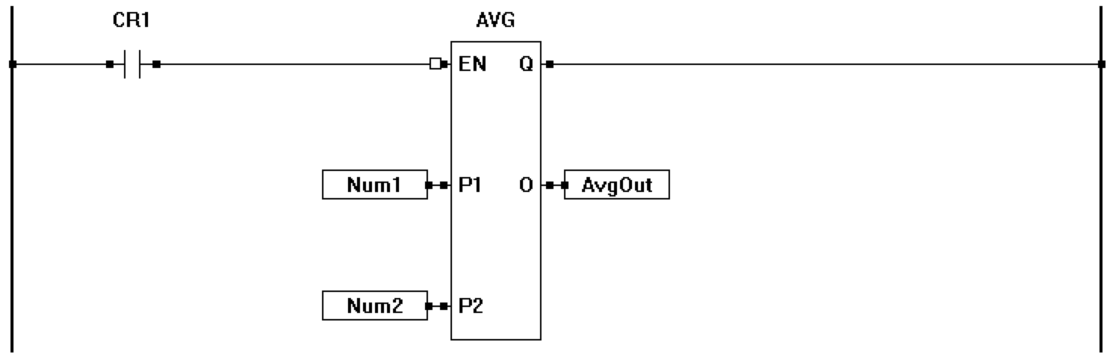
The AVG function averages all the inputs (Px) together and outputs this number (O). The number of inputs is specified when the function is placed in the program. The enable (EN) must be true for the AVG function to be enabled. The Q output is true when the AVG function is enabled.

Input / Output Connections:

The AVG function block placement requires connections of a minimum of three input pins (EN, P1, P2) and two output pins (Q, O). The number of inputs is specified when the function is inserted. The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

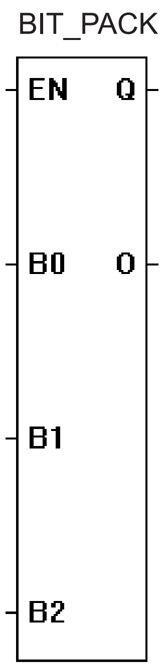
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
Px	Input	X	X				Number of inputs is dynamic
Q	Output			X			
O	Output	X	X				

Example Circuit:



Related Functions: MAVG

BIT_PACK



Description:

The BIT_PACK is a configurable function that will convert the inputs bits (from binary) to a single 32 bit integer number. The Bx inputs are the bits to pack, the EN enables the function when true. The Q output is true when the function is enabled. The output O is the 32-bit integer result of the packed inputs.

The **number of bits** must be identified when the function is placed in the ladder diagram (1-32 bits). Only boolean variables or contacts may be used as bit inputs.

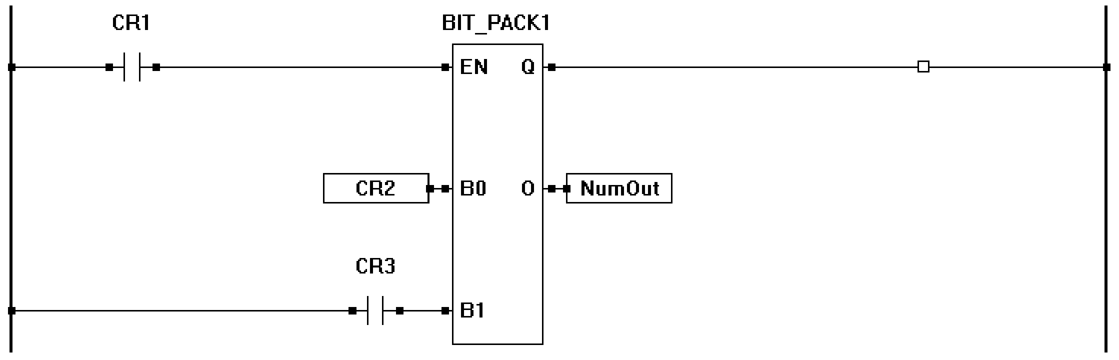
Included in the configuration is the **bit offset**. The bit offset allows the programmer to use multiple BIT_PACK functions and have a single 32 bit output integer by offsetting the bit range for each function block. Note the number of bits + offset bits must be less than or equal to 32.

Input / Output Connections:

The BIT_PACK function block placement requires connections of a minimum of two input pins (EN, B0) and two output pins (Q, O). The number of bits is specified when the function is inserted. The EN is not considered a bit to pack and is not included in the number of bits to pack when placing the function block.

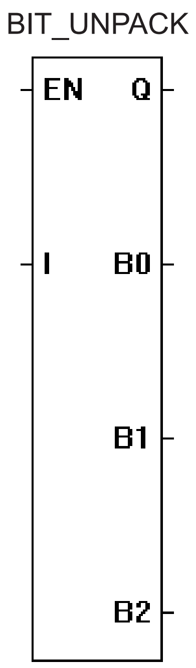
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
Bx	Input			X			Number of Bits is dynamic
Q	Output			X			
O	Output	X					

Example Circuit:



Related Functions: BIT_UNPACK

BIT_UNPACK



Description:

The BIT_UNPACK is a configurable function that will convert a 32 bit integer into up to 32 individual boolean outputs (bits). The I input is the 32 bit integer input, the EN enables the function when true. The Q output is true when the function is enabled. The Bx outputs are the result of the integer being converted to bit outputs (binary equivalent).

The **number of bits** must be identified when the function is placed in the ladder diagram (1-32 bits). Only boolean variables may be used as bit outputs.

Included in the configuration is the **bit offset**. The bit offset allows the programmer to use multiple BIT_UNPACK functions and have a single 32 bit input integer by offsetting the bit range for each function block. Note the number of bits + offset bits must be less than or equal to 32.

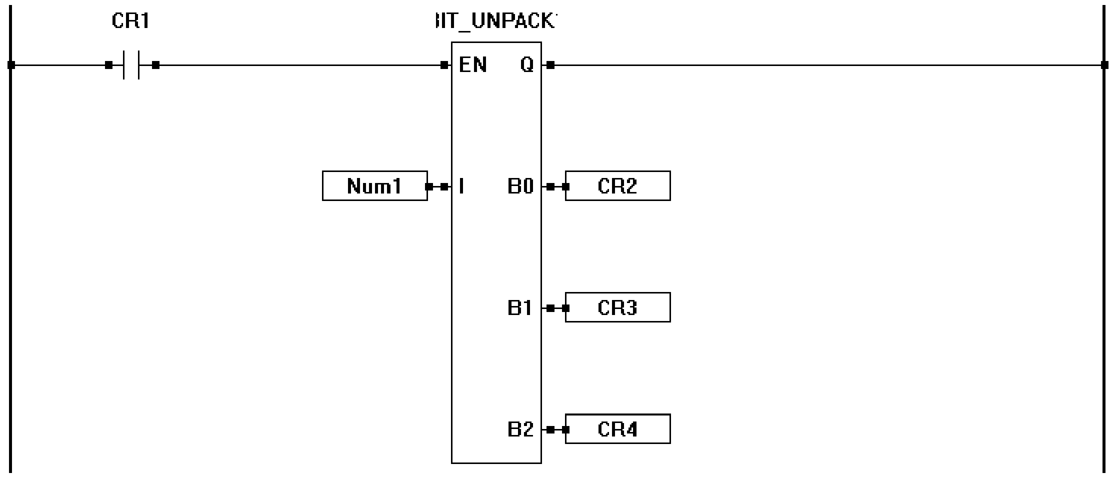
Input / Output Connections:

The BIT_UNPACK function block placement requires connections of two input pins (EN, I) and a minimum of two output pins (Q, Bx). The number of bits is specified when the function is inserted. The EN is not considered a bit to unpack and is not included in the number of bits to unpack when placing the function block.

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
I	Input	X					
Q	Output			X			
Bx	Output			X			Number of Bits is dynamic

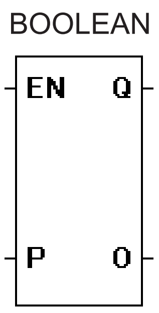
Although the output type for the B*x* bit outputs is boolean, boolean variables must be connected to the B*x* outputs. It is not allowed to connect coils.

Example Circuit:



Related Functions: BIT_PACK

BOOLEAN



Description:

The BOOLEAN function converts the input (P) into a boolean (zero or non-zero) output (O). The enable (EN) must be true for the BOOLEAN function to be enabled. The Q output is true when the BOOLEAN function is enabled.

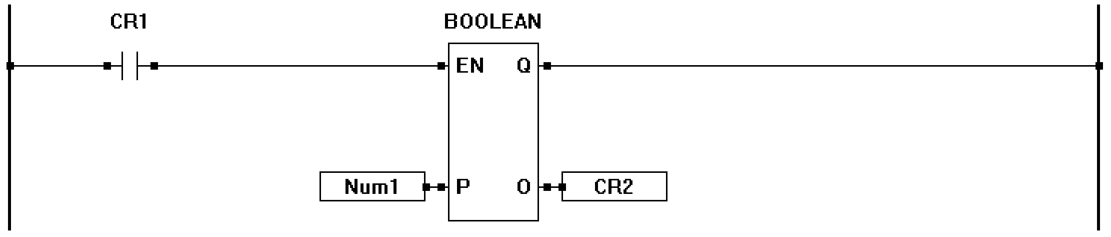
Input / Output Connections:

The BOOLEAN function block placement requires connections of two input pins (EN, P) and two output pins (Q, O).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P	Input	X	X	X			
Q	Output			X			
O	Output			X			

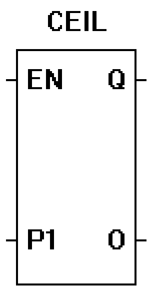
Although the output type for the O output is boolean, a boolean variable must be connected to the O output. A coil may be connected, but compile errors will result.

Example Circuit:



Related Functions: INTEGER, REAL, TIMER

CEIL



Description:

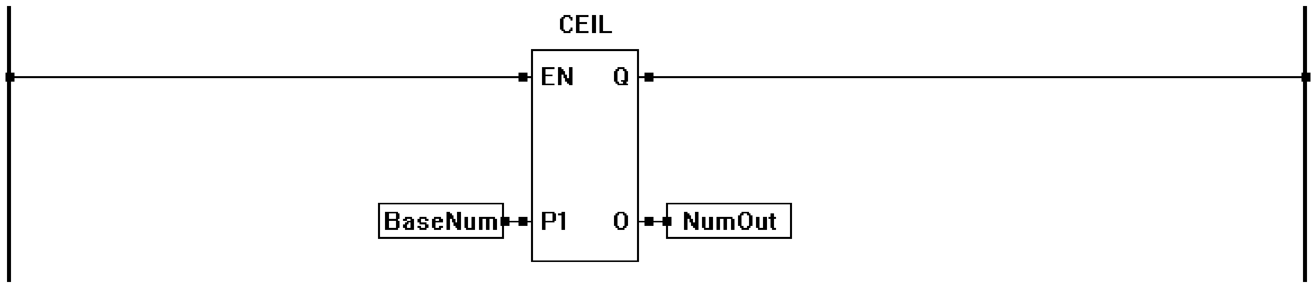
The CEIL function provides a rounded-up result of the P1 Input and outputs this number (O). The enable (EN) must be true for the CEIL function to be enabled. The Q output is true when the CEIL function is enabled.

Input / Output Connections:

The CEIL function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

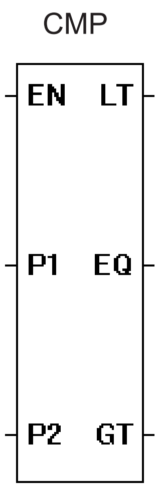
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Rounded Up P1 Base Number

Example Circuit:



Related Functions: FLOOR

CMP



Description:

The CMP function compares the P1 and P2 inputs. LT is true when the P1 input is less than the P2 input. EQ is true when the P1 input equals the P2 input. GT is true when the P1 input is greater than the P2 input. The enable (EN) must be true for the CMP function to be enabled. When the function is disabled, all outputs (LT, GT and EQ) are off.

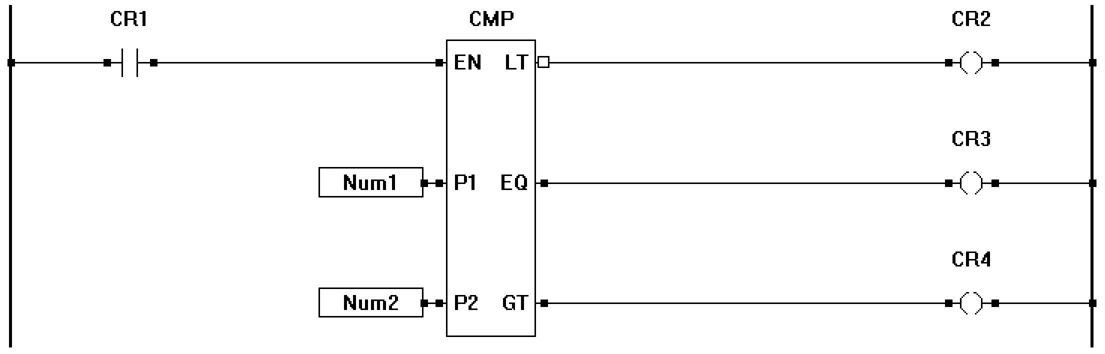
Input / Output Connections:

The CMP function block placement requires connections of three input pins (EN, P1, P2) and three output pins (LT,EQ, GT). There is no Q output on the CMP function block

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X	X				
P2	Input	X	X				
LT	Output			X			
EQ	Output			X			
GT	Output			X			

Although the output type for the LT,EQ and GT outputs is boolean, coils must be connected to the them. A boolean variable may be connected and it will compile, but it will not function on the target.

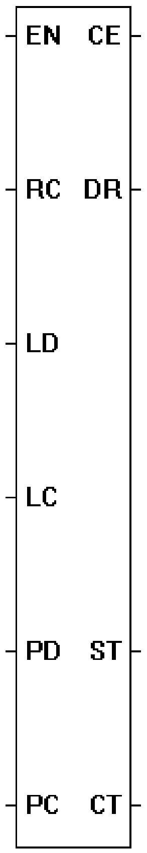
Example Circuit:



Related Functions: LIMIT, HYSTER

CNTR_LS7366R

CNTR_LS7366R



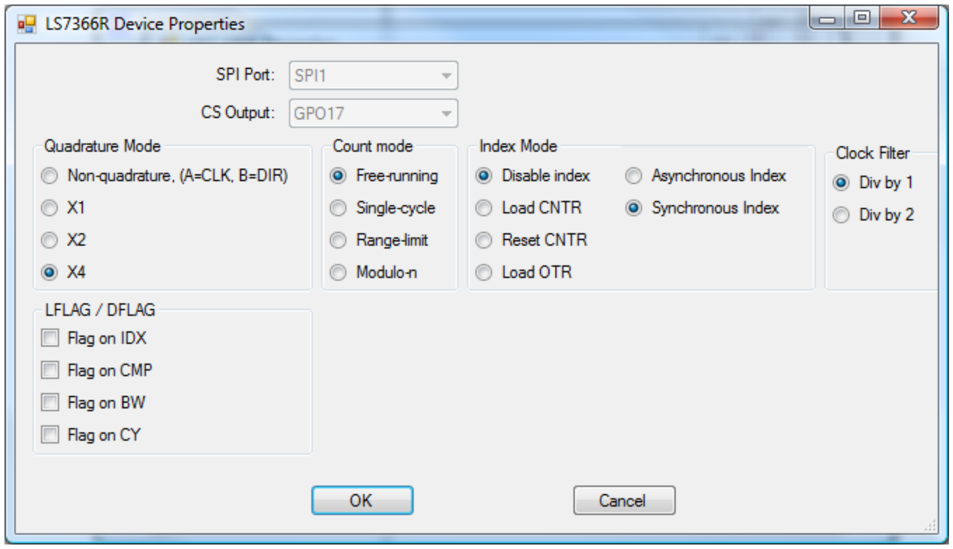
Description:

The CNTR_LS7366R function block is used to read and write to the LS7366R counter integrated circuit. The LS7366R is an integrated circuit that operates as a high speed counter that supports counting up, down and also quadrature. In addition to this function block, the LS7366R must be configured for the application. It is configured in the *Project Settings*. A description of the configuration will follow later in this function block explanation.

The LS7366R operates using internal registers. There are three registers in the LS7366R. OTR, DTR and Actual Count. Per the design of the LS7366R, the actual count register can never be directly read or written to; therefore, the other registers must be used to read and write to the actual count. As an example, when the function block Read Count (RC) input is true, the actual count is copied to the OTR register and then the OTR registers is output at the function blocks count (CT) output. DTR is used to set the count value and may be used as a comparison (see LFLAG/DFLAG).

The first step is to configure the LS7366R. While targets may differ slightly, this configuration is found by clicking the ***Menu...then Project Settings***. Look for a button **LS7366R Properties**. Clicking this button will open the LS7366R Device Properties Window. In this window, configure the LS7366R for the type of application (type of counting along with optional settings).

LS7366R Device Properties Window:


LS7366R Device Properties

SPI Port: SPI1

CS Output: GPO17

Quadrature Mode
- ○ Non-quadrature, (A=CLK, B=DIR)
- ○ X1
- ○ X2
- ● X4

Count mode
- ● Free-running
- ○ Single-cycle
- ○ Range-limit
- ○ Modulo-n

Index Mode
- ● Disable index
- ○ Load CNTR
- ○ Reset CNTR
- ○ Load OTR
- ○ Asynchronous Index
- ● Synchronous Index

Clock Filter
- ● Div by 1
- ○ Div by 2

LFLAG / DFLAG
- ☐ Flag on IDX
- ☐ Flag on CMP
- ☐ Flag on BW
- ☐ Flag on CY

Quadrature Mode

Non-quadrature: Counter input B sets the direction of counting (increase or decrease), and a pulse on input A causes the counter to count by 1.
X1 quadrature: Counter operates in X1 quadrature mode.
X2 quadrature: Counter operates in X2 quadrature mode.
X4 quadrature: Counter operates in X4 quadrature mode.

Count Mode

Free-Running: Free running mode. Counter will wrap in either direction if maximum or minimum value is reached.
Single-cycle: Counter will count until maximum value is reached and then stop counting. Used with CY Flag. Counter must be reset to continue counting.
Range-limit: Counter will only count between zero and the value loaded in the DTR register.
Modulo-n: Actual count will equal number of pulses divided by value of the DTR register + 1.

Index Mode

Disable Index: Index input is disabled and will not cause any action on the actual count register.
Load CNTR: When the index input is active, the actual count register is loaded with the value of the DTR register. The DTR register is loaded using PD and LD on the function block.
Reset CNTR: When the Index input is active, the actual count register is reset to zero.
Load OTR: When the index input is active, the OTR register is loaded with the actual count register value. The OTR register is used to read the current count.
Asynchronous Index: In quadrature mode, if index is active, it is applied (acted on) regardless of its phase relationship to inputs A and B.
Synchronous Index: In quadrature mode, If index is active, it must meed the phase relationship of inputs A and B before it can be applied (acted on).

Clock Filter

Div by 1: Filter Frequency divided by 1. This is based on the input frequency of A and B inputs.
Div by 2: Filter Frequency divided by 2. This is based on the input frequency of A and B inputs.

LFLAG/DFLAG

Flag on IDX: When index is true, the LFLAG will set and latch, while DFLAG will be set only while the condition is maintained.
Flag on CMP: When actual count value = value of the DTR register, the LFLAG will set and latch, while DFLAG will be set only while the condition is maintained.
Flag on BW: When enabled, when counter wraps from zero to maximum, the LFLAG will set and latch, while DFLAG will be set only while the condition is maintained.
Flag on CY: When enabled, when counter wraps from maximum to zero, the LFLAG will set and latch, while DFLAG will be set only while the condition is maintained.

The DFLAG and LFLAG is typically read using digital inputs that are specific to each target. Refer to the target's User Manual.

In addition to the hardware inputs that control the LS7366R, the CNTR_LS7366R function block is used in EZ LADDER to read the count, reset the count and control the registers.

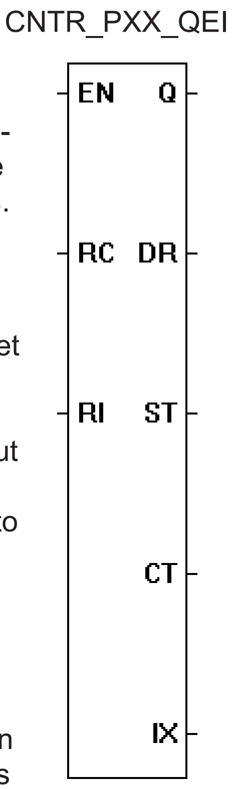
Function Block Inputs:

EN:	Function block enable (Boolean). When true, the function block is enabled.
RC:	Read Count Input (Boolean). When true, the actual count is internally copied to OTR and then OTR is output at the count output (CT). When false, the OTR is output at the count output (CT) without copying the actual count.
LD:	Load DTR input (Boolean). When true, the DTR register is loaded with the value of the variable connected to the PD input. When using LC and LD, LC has a higher priority and will execute first before LD.
LC:	Load Counter input (Boolean). When true, the value of PC is loaded into the DTR register and then the DTR register is copied to the actual count. When using LC and LD, LC has a higher priority and will execute first before LD.
PD:	Value (Integer) to be loaded into DTR when LD input is true.
PC:	Value (Integer) to be loaded into DTR and then actual count when LC is true.

Function Block Outputs:

CE:	Output (Boolean) is true when the function block is enabled and no errors are present.
DR:	Direction output (Boolean). Identifies the current count direction (0 or 1).
ST:	Status output (Integer). The output provides a numeric represtation of the status of the LS7366R current function. Consult factory if more information is required.
CT:	Current Count (Integer).

CNTR_PXX_QEI



Description:

The CNTR_PXX_QEI function block is used to read the current position of a quadrature encoder connected to the quadrature encoder inputs. For more details on how the quadrature counter inputs and function blocks operate together, see **Chapter 18 - Counters & Timers**.

The enable (EN) input must be true for the CNTR_PXX_QEI function block to operate. The Q output is true when the function block is enabled. The reset position counter input (RC) will reset the internal position counter when true. The reset index counter input (RI) will reset the internal index counter when true.

The direction output (DR) identifies the direction of encoder travel (0 or 1). The status output (ST) identifies the current status of the encoder. The position counter value output (CT) will be equal to the current encoder position. The index counter value output (IX) will be equal to the current index counter (number of time the encoder has passed its maximum position).

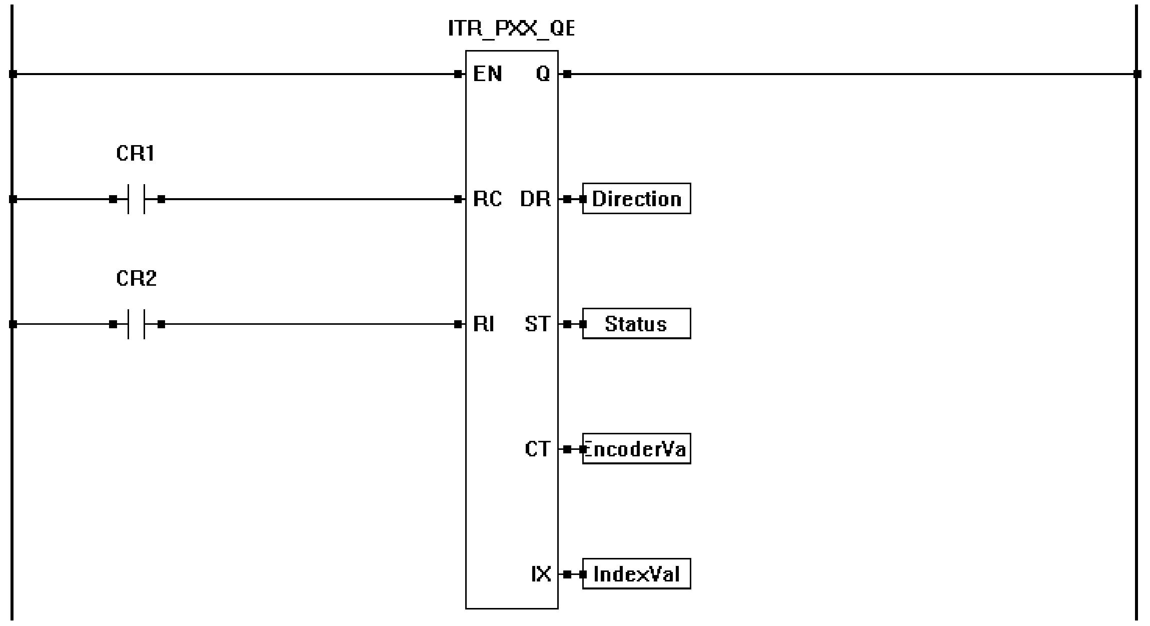
IX is incremented and decremented as needed when the current encoder position either passes its maximum position or its minimum position.

The quadrature encoder must be installed in the Project Settings before this function block may be placed. Other parameter configurations must be completed during this installation. Refer to **Chapter 18 - Counters & Timers**.

Based on the qudarature encoder input configuration in the Project Settings menu, as the encoder moves in the forward direction, when the position exceeds the maximum value, the index counter is incremented and the position is set to zero. As the encoder moves in a reverse direction, when the position reaches 0, the index counter is decremented and the position is set to the maximum.

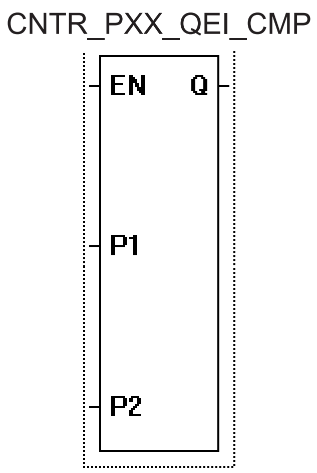
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
RC	Input			X		Active True	Resets Position Counter (CT)
RI	Input			X		Active True	Resets Index Counter (IX)
DR	Output			X			Direction of Encoder Travel (0 or 1)
ST	Output	X					Status of Encoder
CT	Output	X					Current Value Encoder Position
IX	Output	X					Current Value of Idex Counter
Q	Output			X			

Example Circuit:



Related Functions: CNTR_PXX_QEI_CMP, CNTR_PXX_QEI_VEL

CNTR_PXX_QEI_CMP



Description:

The CNTR_PXX_QEI_CMP function block is used to load values into compare registers (3 available for Position Counter and 3 avaliable for Index Counter). For more details on how the quadrature counter inputs and function blocks operate together, see **Chapter 18 - Counters & Timers**.

When the function block is placed, a dialog box is automatically displayed (See next page). The Compare drop-down menu is used to select the type of compare to use (load and monitor).

The enable (EN) input must be true for the CNTR_PXX_QEI_CMP function block to operate.

The Q Output is based on the type of compare and the actual count value.

The quadrature encoder must be installed in the Project Settings before this function block may be placed. Other parameter configurations must be completed during this installation. Refer to **Chapter 18 - Counters & Timers**.

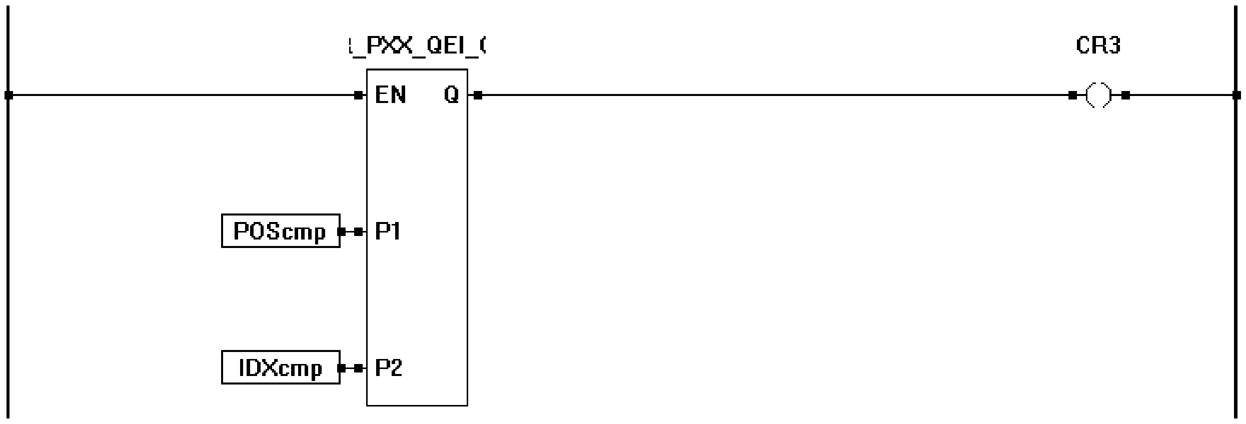
Three hardware compare registers are provided for the Position Counter compare. These are listed as CMP0, CMP1 and CMP2 in the drop-down menu in the dialog. When a CMPx is selected, the value connected to the P1 input is compared to the Position Counter and the Q is true if these values are equal. As three compare registers are provided, using three different instances of this function block with different CMPx selected will provide three individual compares that may be made to the Position Counter.

Three hardware compare registers are provided for the Index Counter compare. These are listed as IDX0, IDX1 and IDX2 in the drop-down menu in the dialog. When a IDXx is selected, the value connected to the P1 input is compared to the Index Counter and the Q is true if these values are equal. As three compare registers are provided, using three different instances of this function block with different IDXx selected will provide three individual compares that may be made to the Index Counter.

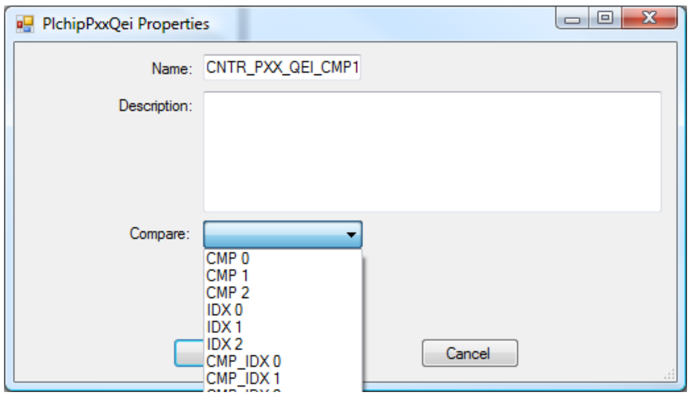
Additionally, these two features (Position Counter Compare and Index Counter Compare) may be combined by this function block. The combination requires the postion counter and index counter each equal their respective Px inputs to the function block. These items are listed as CMP_IDX0, CMP_IDX1, CMP_IDX2. When using the CMP_IDXx item, the P1 input is the compare value for the Position Counter and the P2 input is the compare value for the Index Counter. The Q Output is true when both the Position Counter equals the P1 input and the Index Counter equals the P2 input. As three compare registers are provided, using three different instances of this function block with different CMP_IDXx selected will provide three individual compares that may be made to the both the Position and Index Counters.

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X					Compare Value for Position Counter
P2	Input	X					Compare Value for Index Counter
Q	Output			X			True when Compare values are true

Example Circuit:



Dialog Box:



Name: CNTR_PXX_QEI_CMP1

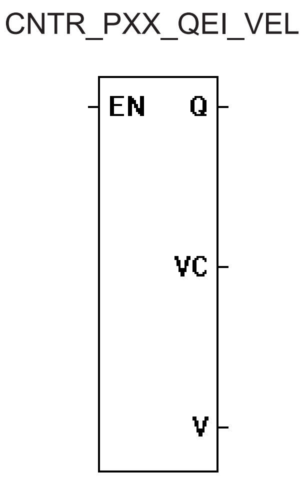
Description:

Compare:

CMP 0
CMP 1
CMP 2
IDX 0
IDX 1
IDX 2
CMP_IDX 0
CMP_IDX 1

Related Functions: CNTR_PXX_QEI, CNTR_PXX_QEI_VEL

CNTR_PXX_QEI_VEL



Description:

The CNTR_PXX_QEI_VEL function block is used to convert quadrature input counts into a velocity based on engineering units.

When the function block is placed, a dialog box is automatically displayed (See next page). The Sample Period in seconds and the Pulses per Revolution is set using the dialog box.

The quadrature encoder must be installed in the Project Settings before this function block may be placed. Other parameter configurations must be completed during this installation. Refer to **Chapter 18 - Counters & Timers**.

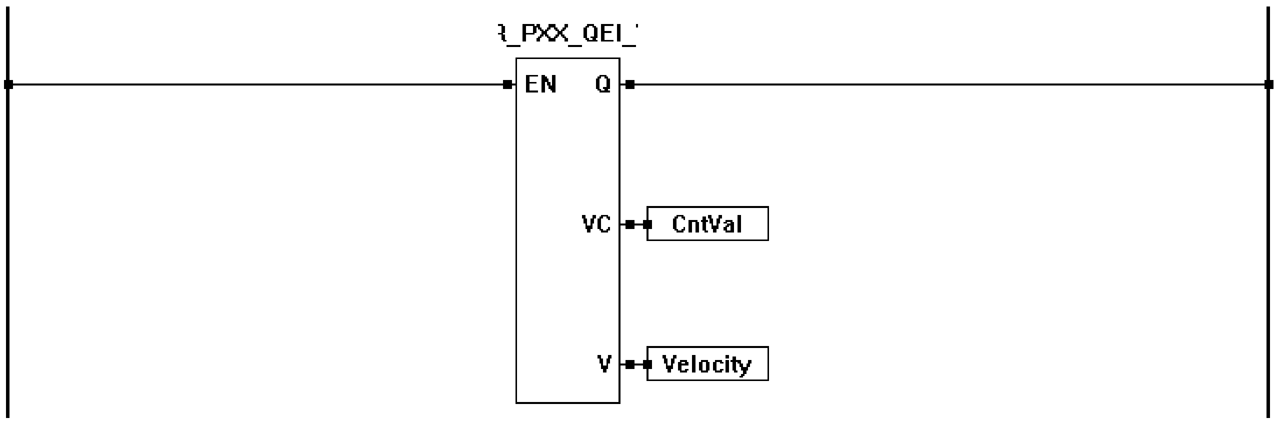
The enable (EN) input must be true for the CNTR_PXX_QEI_VEL function block to operate. The function block counts pulses on the quadrature inputs over the time set by the Sample Period in seconds. It uses the pulses per revolution, the Sample Period and the actual counts to calculate the velocity.

The actual velocity (in engineering units) is output on the V output. The VC output is the number of pulses counted in the sample period. The Q output is true only for the ladder diagram *scan* when the velocity is calculated and updated on the V output.

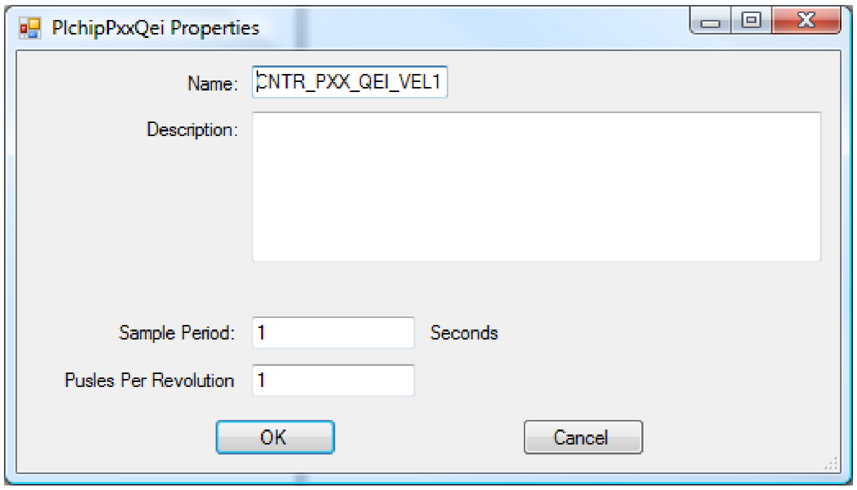
If the Pulses per Revolution is 1, then the V output is equal to the counter frequency. If not set to 1, then the V output will be revolutions per second.

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
VC	Output	X					Number of Pulses in Sample Period
V	Output		X				Velocity in Revolutions per second
Q	Output			X			True for Scan when Velocity is updated

Example Circuit:



Dialog Box:



Name: CNTR_PXX_QEI_VEL1

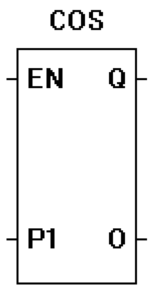
Description:

Sample Period: 1 Seconds

Pusles Per Revolution 1

Related Functions: CNTR_PXX_QEI, CNTR_PXX_QEI_CMP

COS



Description:

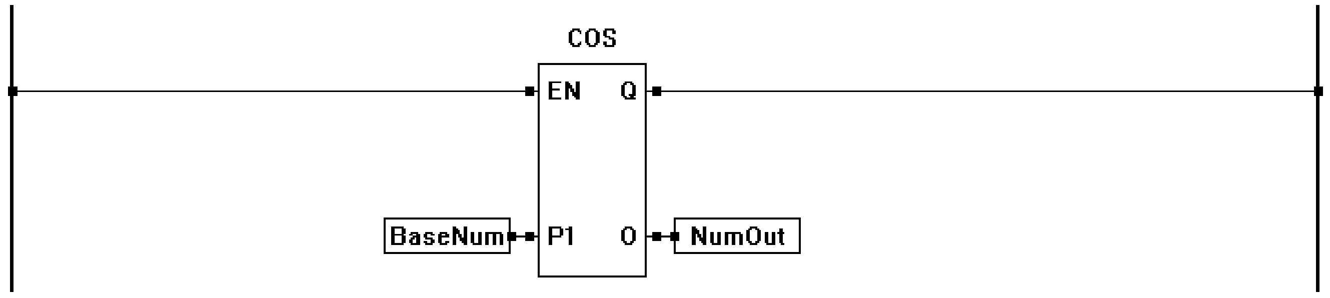
The COS function provides a cosine (O) from the input value (P1). The enable (EN) must be true for the COS function to be enabled. The Q output is true when the COS function is enabled.

Input / Output Connections:

The COS function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

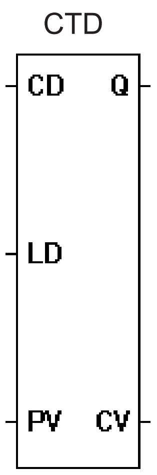
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Cosine Output of P1 Base Number

Example Circuit:



Related Functions: ACOS, ASIN, ATAN, SIN, TAN

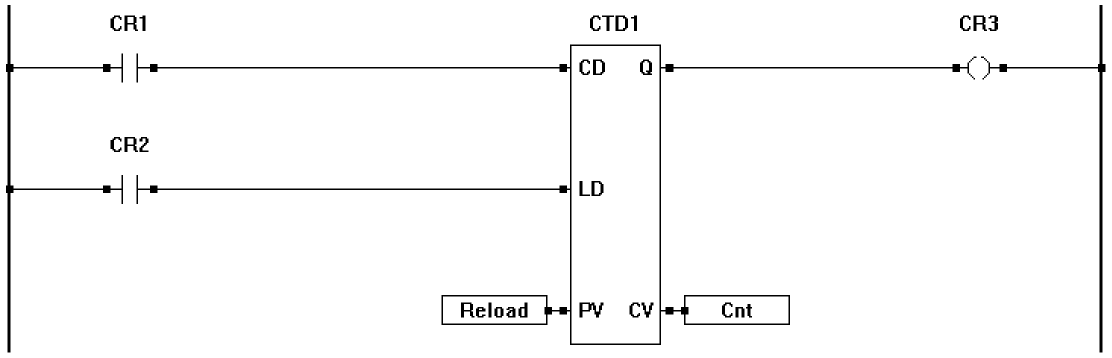
CTD

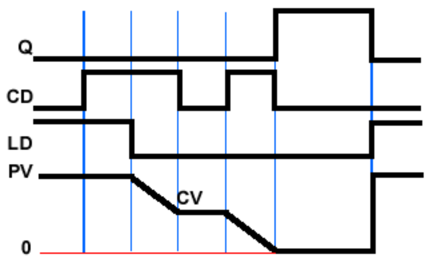


Description:
The CTD function is a programmable software down counter. A true on CD will cause the counter to decrement by one. Once the counter (CV) equals zero, the Q output will be true. A true on LD will cause the counter to load the PV as the current (CV) count and reset the Q output. The down counter triggers on a false to true transition on the CD input.

Input / Output Connections:
The CTD function block placement requires connections of three input pins (CD, LD, PV) and two output pins (Q,CV).

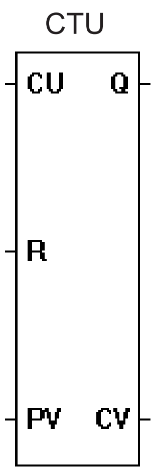
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
CD	Input			X		Rising Edge	
LD	Input			X			
PV	Input	X					
Q	Output			X			True when CV=0
CV	Output	X					

Example Circuit:


Timing Diagram:


Related Functions: CTU, CTUD

CTU



Description:

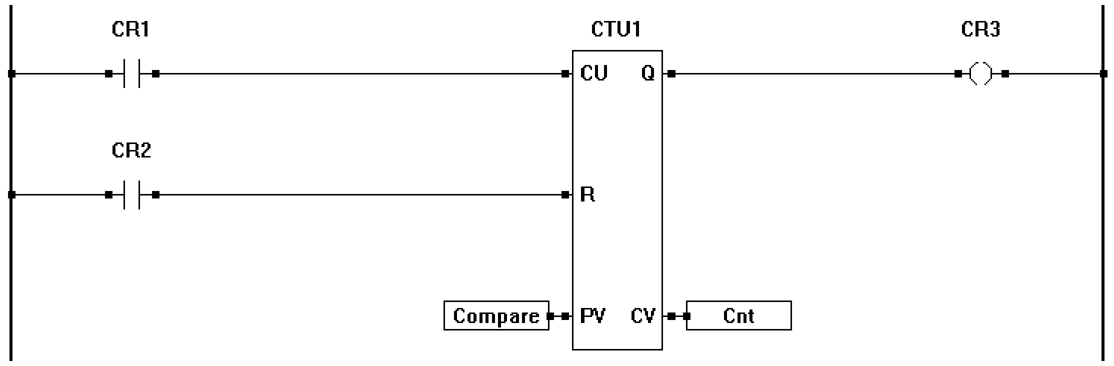
The CTU function is a programmable software up counter. A true on CU will cause the counter to increment by one. Once the counter (CV) equals the preset value (PV), the Q output will be true. A true on reset (R) will cause the counter reset to zero and reset the Q output. The down counter triggers on a false to true transition on the CU input.

Input / Output Connections:

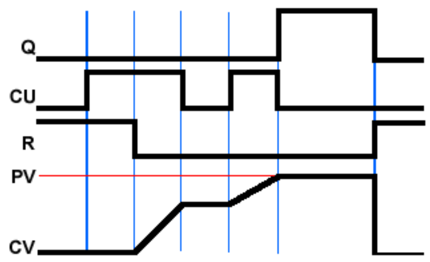
The CTU function block placement requires connections of three input pins (CU, R, PV) and two output pins (Q,CV).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
CU	Input			X		Rising Edge	
R	Input			X			
PV	Input	X					
Q	Output			X			True when CV=PV
CV	Output	X					

Example Circuit:

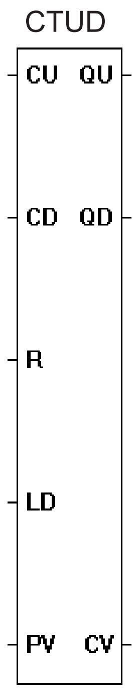


Timing Diagram:



Related Functions: CTD, CTUD

CTUD



Description:

The CTUD function is programmable software up and down counter. This counter is a combination of the CTU and CTD; therefore, it can count up and down based on the count inputs as well as the Reset and Load inputs.

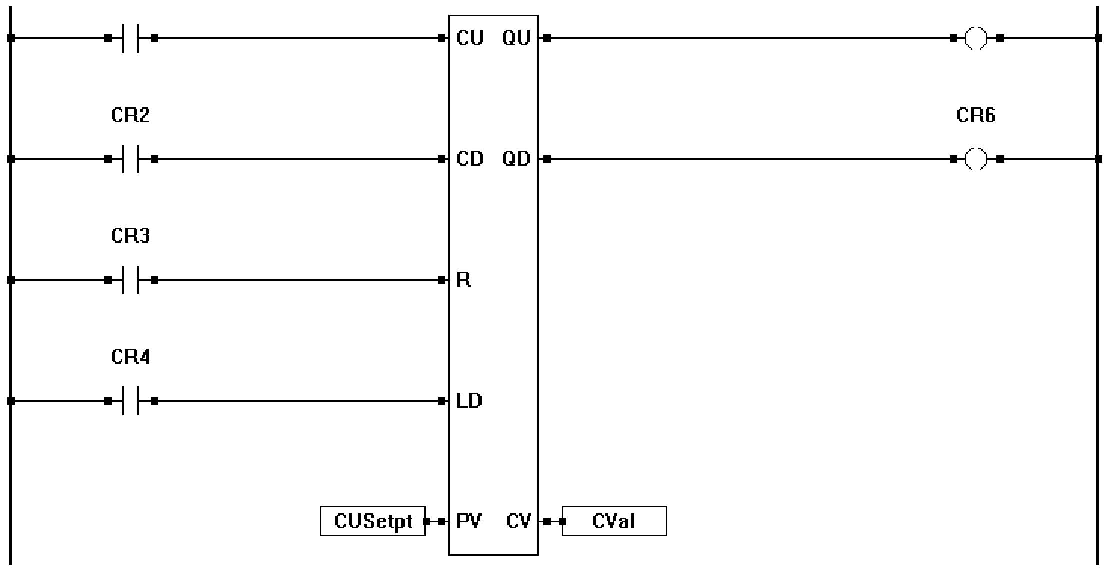
With reset (R) not active, a true on input (CU) will increment the current (CV) count by one, while a true on input (CD) will cause the current count (CV) to decrement by one. When the CV = PV, the output (QU) will be true. When the CV = 0, the output (QD) will be true. A true on the reset (R) will cause CV = 0, QU to go false and QD to go true. A true on the load (LD) will cause CV = PV, QU to go true and QD to go false. The reset (R) is dominant and takes priority over all inputs. The counter inputs trigger on a false to true transition on CU or CD.

Input / Output Connections:

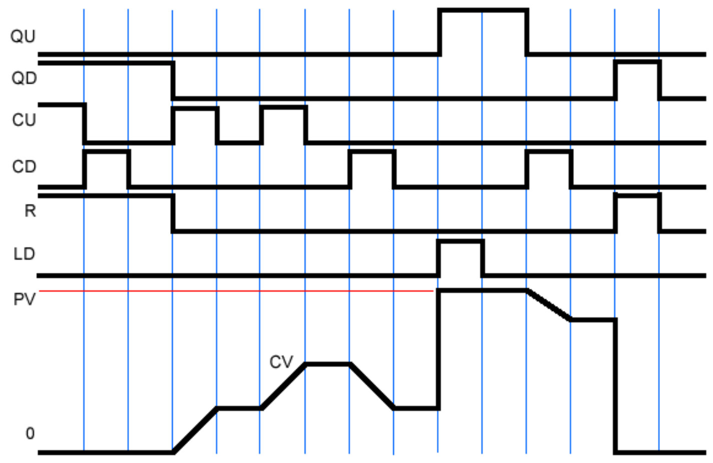
The CTUD function block placement requires connections of five input pins (CU, CD, R, LD, PV) and three output pins (QU, QD, CV).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
CU	Input			X		Rising Edge	
R	Input			X			Reset is dominant
CD	Input			X		Rising Edge	
LD	Input			X			
PV	Input	X					
QU	Output			X			True when CV=PV
QD	Output			X			True when CV=0
CV	Output	X					

Example Circuit:



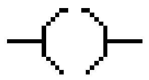
Timing Diagram:



Related Functions: CTU, CTD

DIRECT COIL

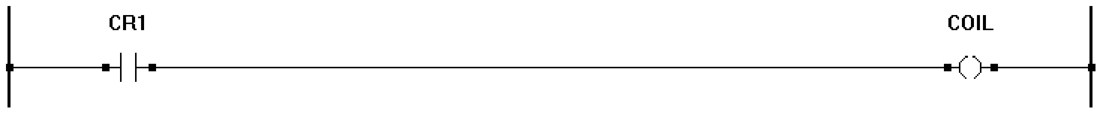
DIRECT COIL



Description:

The DIRECT COIL is a representation of an internal boolean variable output (coil) or an actual hardware (real world) output. Its normal state is false or normally de-energized. An internal DIRECT COIL may also be referred to as a *control relay* (CR). If there is *power flow* to the DIRECT COIL, then it will be true (on). If there is no *power flow* to the DIRECT COIL, then it will be false (off). The DIRECT COIL may only be placed in the last column.

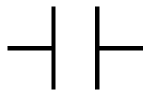
Example Circuit:



Related Functions: INVERTED COIL, DIRECT CONTACT, INVERTED CONTACT

DIRECT CONTACT

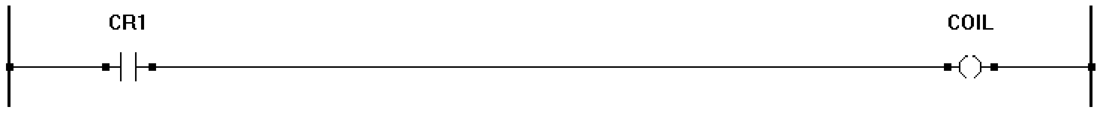
DIRECT CONTACT



Description:

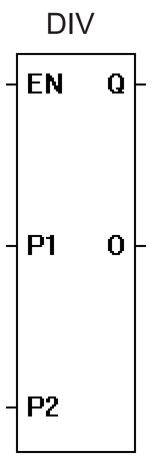
The DIRECT CONTACT is a representation of an internal boolean variable input or an actual hardware (real world) input. Its normal state is false or normally de-energized. An internal DIRECT CONTACT may also be referred to as a *control relay* (CR). A true condition on the input (if internal coil is true for internal contacts or real world input is true), then the contact will allow *power flow* and devices located to the right of the DIRECT CONTACT may operate.

Example Circuit:



Related Functions: DIRECT COIL, INVERTED COIL, INVERTED CONTACT

DIV



Description:

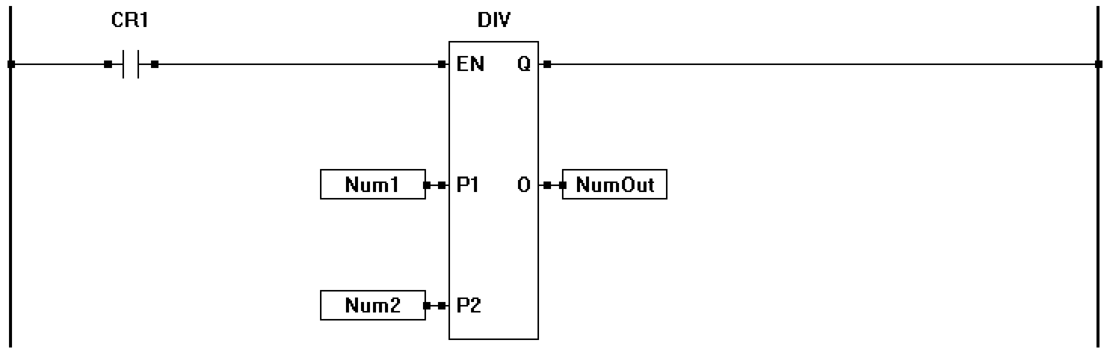
The DIV function divides the P1 input by the P2 input and outputs the result (O). The enable (EN) must be true for the DIV function to be enabled. The Q output is true when the DIV function is enabled. The result (O) is the whole number quotient only. No remainder is provided.

Input / Output Connections:

The DIV function block placement requires connections of three input pins (EN, P1, P2) and two output pins (Q,O).

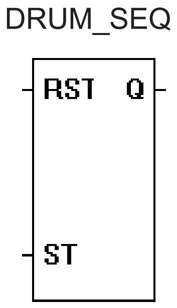
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X	X				
P2	Input	X	X				
Q	Output			X			
O	Output	X	X				O=P1/P2

Example Circuit:



Related Functions: ADD, SUB, MULT

DRUM_SEQ



Description:

The DRUM_SEQ function is comprised of a matrix table of steps (rows of table) and the channels (columns of table). For each channel, a boolean variable (to be used as a contact) is automatically created. A DRUM_SEQ always starts in step 1. Each false to true transition on the ST input will cause the step to increment to the next. The DRUM_SEQ will wrap to step 1 after the last step. A true on RST will reset the DRUM_SEQ to step 1. RST is dominant and will not allow the DRUM_SEQ to step when true.

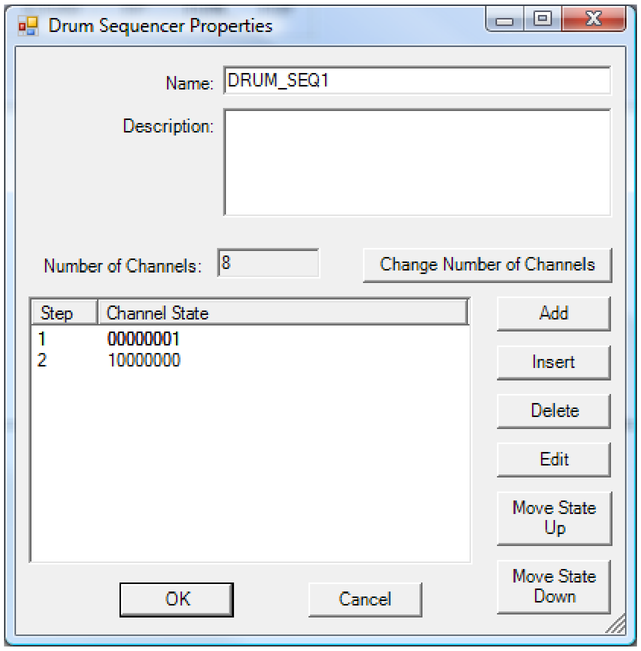
Each step stores a unique setting for each channel. This setting can be set as on or off (true, false). As a contact is created to represent each channel, when a DRUM_SEQ changes steps, each channel is automatically set to the state the channel in that step.

Input / Output Connections:

The DRUM_SEQ function block placement requires connections of two input pins (RST, ST) and one output pin (Q). In addition, a boolean variable to be used as a contact is created for each channel. A maximum of 32 channels is permitted per DRUM_SEQ. The matrix table is completed when the function is placed.

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
RST	Input			X			RST is dominant
ST	Input			X			
Q	Output			X			

Configuring the number of channels, setting channel states and adding steps is handled using the DRUM Sequencer Properties dialog box. This box is displayed when placing a DRUM_SEQ function block. Use the buttons provided to add, insert, delete and edit steps. The order of steps may also be changed.



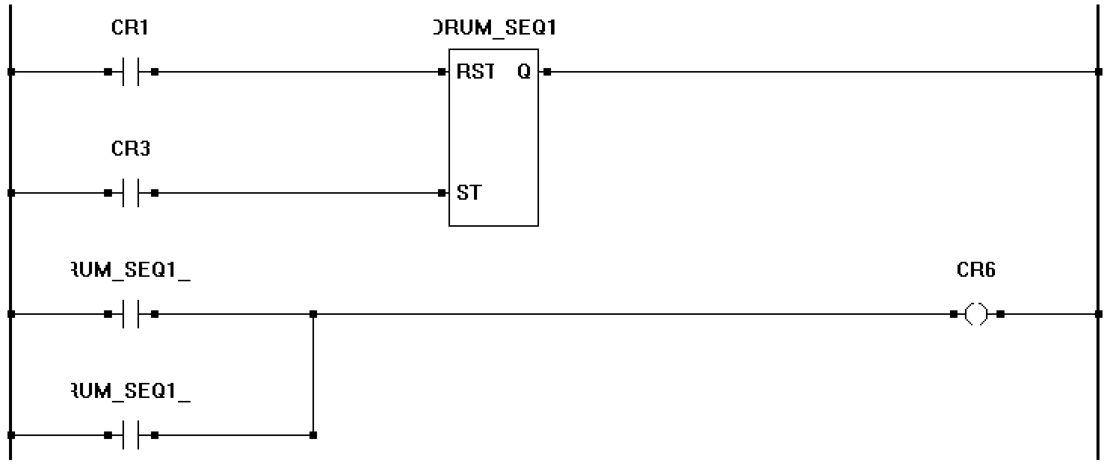
Name: DRUM_SEQ1

Description:

Number of Channels: 8

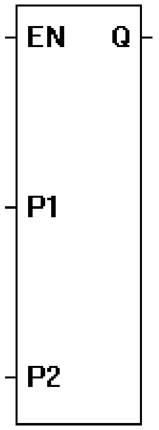
Step	Channel State
1	00000001
2	10000000

Example Circuit:



EQUAL TO (=)

EQUAL TO



Description:

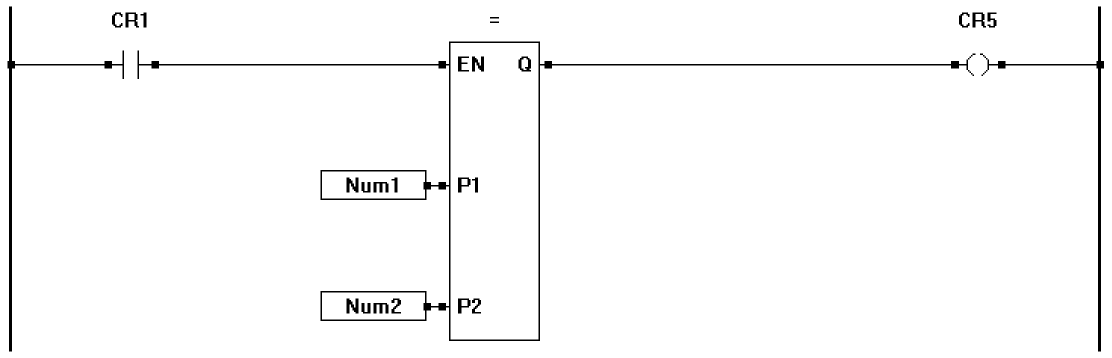
The EQUAL TO function provides an equal to comparison for the Px inputs. The number of inputs is specified when the object is placed. The Q output is true if all the Px inputs are equal. The Enable must be true for the EQUAL TO function to be enabled.

Input / Output Connections:

The EQUAL TO function block placement requires connections of at least three input pins (EN, P1, P2) and one output pin (Q). The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

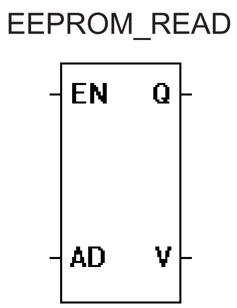
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P*x*	Input	X	X				Number of inputs is dynamic
Q	Output			X			True when all P**x** are equal

Example Circuit:



Related Functions: <>, <, >, <=, >=

EEPROM_READ



Description:

The EEPROM_READ recalls variables stored in non-volatile memory (EEPROM). The function is enabled when a false to true is seen on EN. AD provides the actual address to read from and V is the actual value that is read from the EEPROM. Q is true when the read cycle has completed.

The same variable type that writes to the EEPROM location should be used to read the EEPROM location. A memory map is recommended for organizing variables stored in EEPROM.

Each EEPROM address is absolute and is one byte in size. Boolean variables fill two bytes while all other variable types fill four bytes of EEPROM. When reading variables from EEPROM storage, it is important that use the exact address location for the variable only (taking into account variable types and sizes).

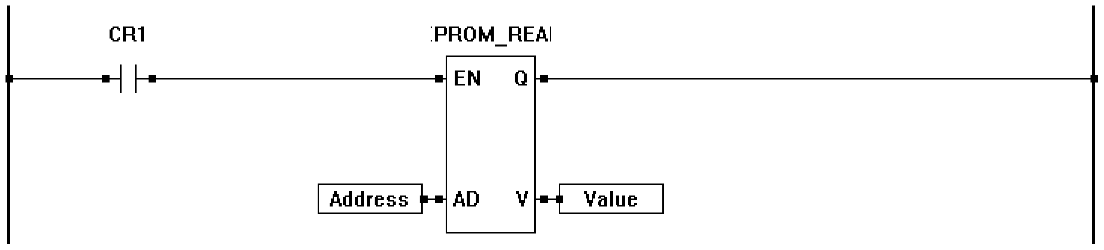
See EEPROM_WRITE for more on how variables are written to EEPROM storage.

Input / Output Connections:

The EEPROM_READ function block placement requires connections of two input pins (EN, AD) and two output pins (Q, V).

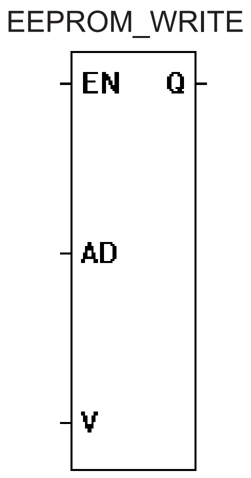
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Rising Edge	
AD	Input	X					
Q	Output			X			
V	Output	X	X	X	X		

Example Circuit:



Related Functions: EEPROM_WRITE

EEPROM_WRITE



Description:

The EEPROM_WRITE function allows variables to be stored in non-volatile memory (EEPROM). The function is enabled when the EN sees a false to true transition. AD provides the actual address to write to EEPROM and V is the actual value that is written. Q is true when the write cycle has completed without error.

The same variable type that writes to the EEPROM location should be used to read the EEPROM location. A memory map is recommended for organizing variables stored in EEPROM.

Writing to EEPROM is a relatively slow operation and this must be considered when creating the ladder diagram project as scan time can be affected during a write.

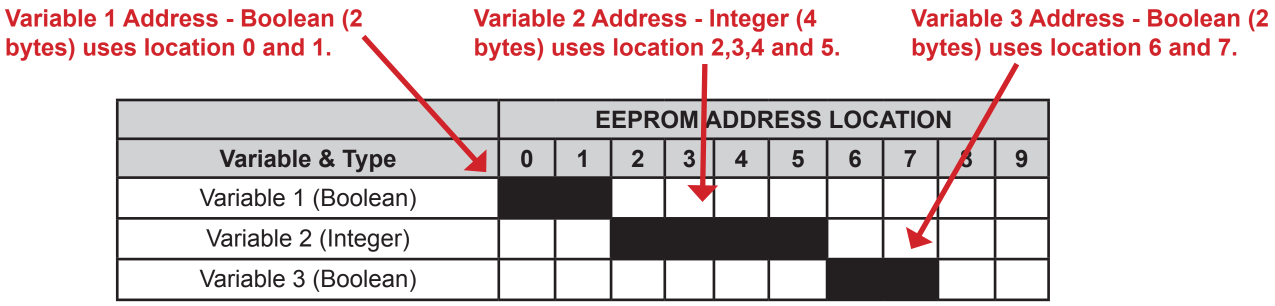
EEPROM storage area has a limited number of write cycles; therefore it shouldn’t be used to store data which changes often and must be re-written often. Writing often to the same location can cause the location to fail.

Input / Output Connections:

The EEPROM_WRITE function block placement requires connections of three input pins (EN, AD, V) and one output pin (Q).

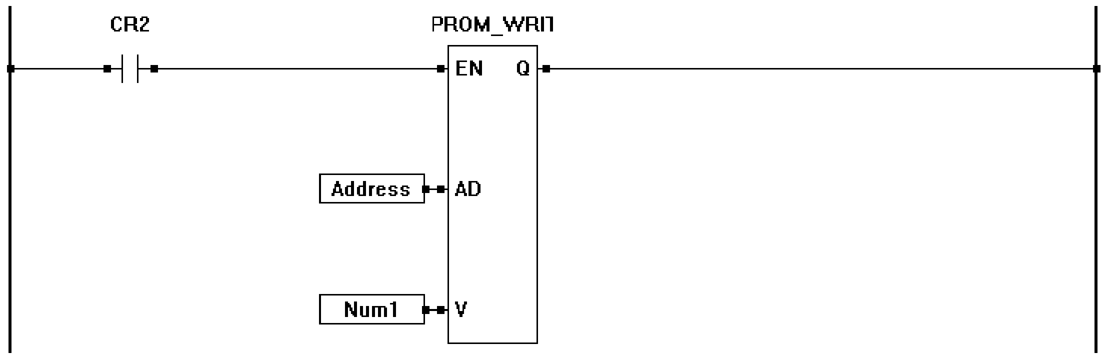
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Rising Edge	
AD	Input	X					
V	Input	X	X	X	X		
Q	Output			X			

Each EEPROM address is absolute and is one byte in size. Boolean variables fill two bytes while all other variable types fill four bytes of EEPROM. When writing a boolean to address 0, the actual variable will use addresses 0 and 1 (two bytes). Should you write an integer variable into address 0, then it would use addresses 0-3. A memory map should be created and used to assign variable types and addresses prior to coding to ensure that variable size and types are accounted for.


Variable 1 Address - Boolean (2 bytes) uses location 0 and 1.
Variable 2 Address - Integer (4 bytes) uses location 2,3,4 and 5.
Variable 3 Address - Boolean (2 bytes) uses location 6 and 7.

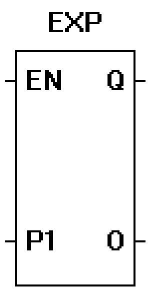
	EEPROM ADDRESS LOCATION									
Variable & Type	0	1	2	3	4	5	6	7	8	9
Variable 1 (Boolean)	■	■								
Variable 2 (Integer)			■	■	■	■				
Variable 3 (Boolean)							■	■		

Example Circuit:



Related Functions: EEPROM_READ

EXP



Description:

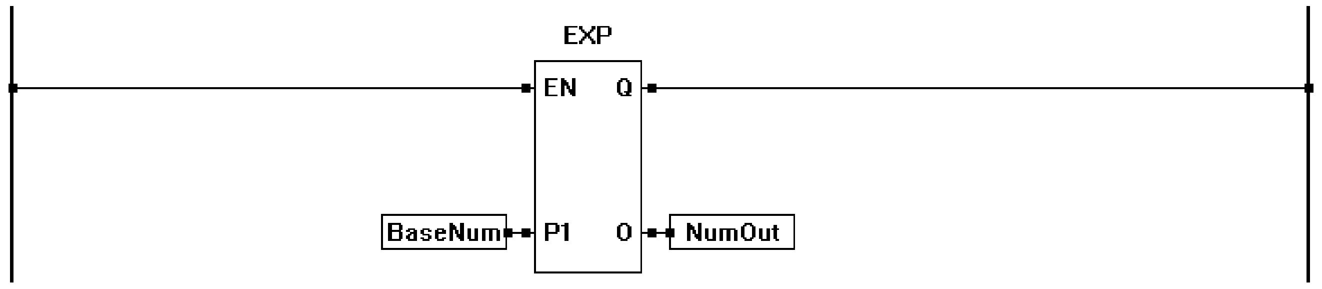
The EXP function provides the natural exponential of the P1 input. The output (O) is the natural exponential of the P1 input. The enable (EN) must be true for the EXP function to be enabled.

Input / Output Connections:

The EXP function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

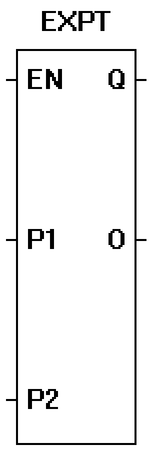
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Natural Exponential of P1

Example Circuit:



Related Functions: EXPT, LN, SQRT. LOG

EXPT



Description:

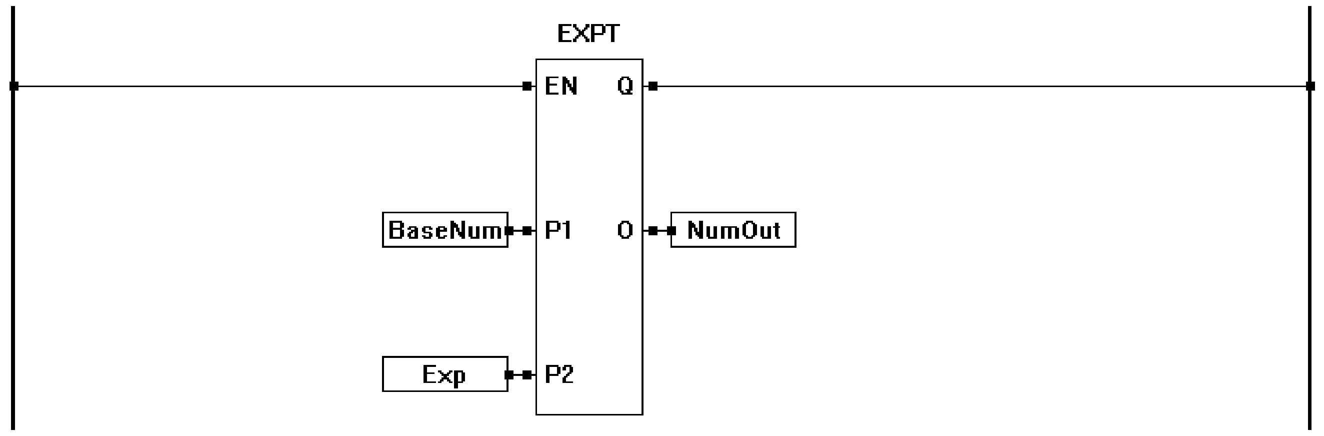
The EXPT function provides the exponentiation of the P1 and P2 inputs. The output (O) is the is the result of the exponentiation (P1P2). The enable (EN) must be true for the EXPT function to be enabled.

Input / Output Connections:

The EXPT function block placement requires connections of three input pins (EN, P1, P2) and two output pins (Q, O).

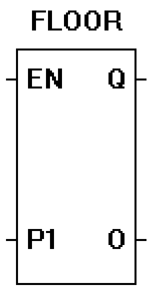
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
P2	Input		X				Exponent Number
Q	Output			X			
O	Output		X				Result of Exponentiation

Example Circuit:



Related Functions: EXP, LN, SQRT, LOG

FLOOR



Description:

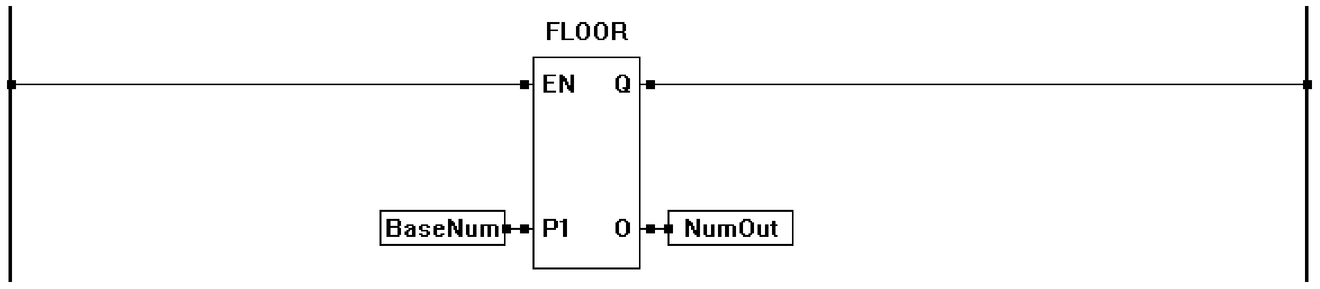
The FLOOR function provides a rouned-down output of P1 input. The output (O) is the is the rounded-down number. The enable (EN) must be true for the FLOOR function to be enabled.

Input / Output Connections:

The FLOOR function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

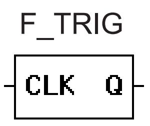
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Rounded Down P1 Base Number

Example Circuit:



Related Functions: CEIL

F_TRIG



Description:

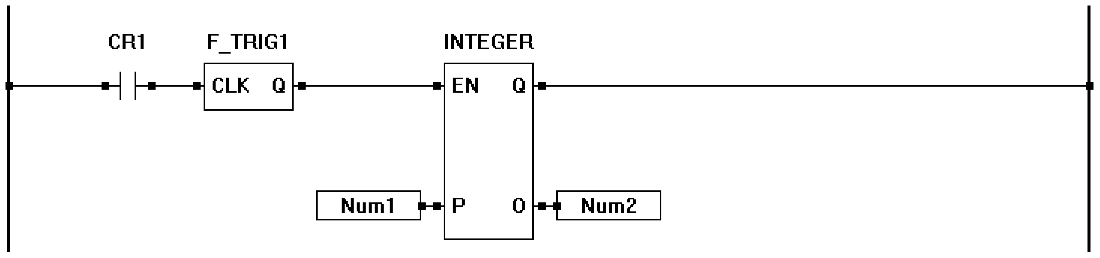
The F_TRIG is a function that may be used to trigger another function on the falling edge of a transition. When the CLK detects a true to false transition, the output (Q) is energized for one scan of the program only.

Input / Output Connections:

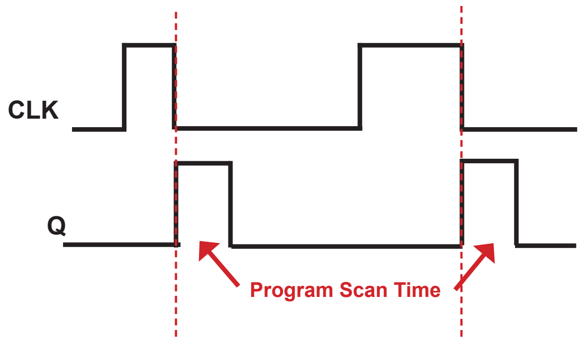
The F_TRIG function block placement requires connections of one input pin (CLK) and one output pin (Q).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
CLK	Input			X		Falling Edge	
Q	Output			X			True for only one scan

Example Circuit:

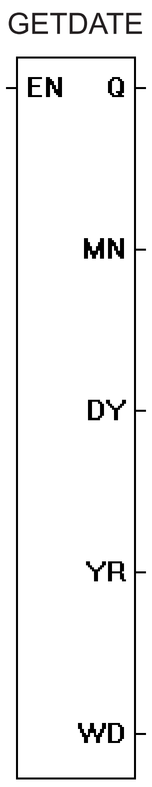


Timing Diagram:



Related Functions: R_TRIG

GETDATE



Description:

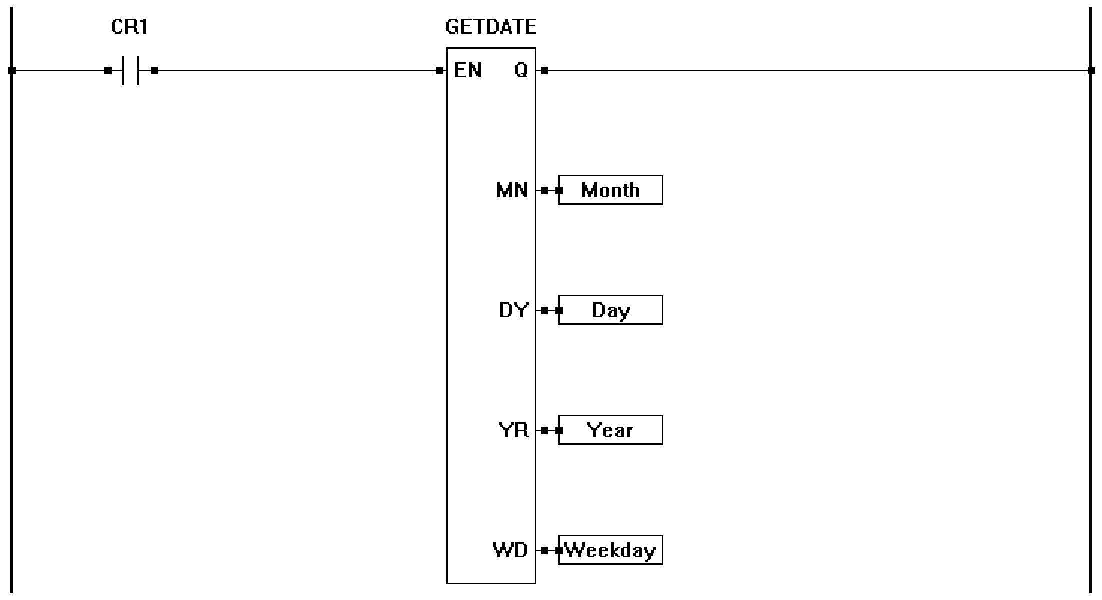
The GETDATE function reads the current date from the hardware real time clock. The values of the date are stored into the integer variables on the output pins. The enable (EN) must be true for the GETDATE function to be enabled. The Q output is true when the function is enabled. The MN output returns the month (1-12), the DY output returns the day of the month (1-31) , the YR output returns the current year (last two digits) and the WD returns the day of the week (1-7, 1=Sunday). The MN, DY, YR and WD outputs must be connected to Integer variables.

Input / Output Connections:

The GETDATE function block placement requires connections of one input pin (EN) and five output pins (Q, MN, DY, YR, WD).

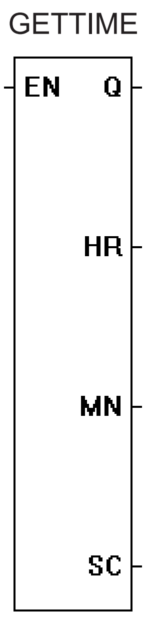
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State
EN	Input			X		Active True
Q	Output			X		
MN	Output	X				
DY	Output	X				
YR	Output	X				
WD	Output	X				

Example Circuit:



Related Functions: GETTIME, SETTIME, SETDATE

GETTIME



Description:

The GETTIME function reads the current time from the hardware real time clock. The values of the time are stored into the integer variables on the output pins. The enable (EN) must be true for the GETTIME function to be enabled.

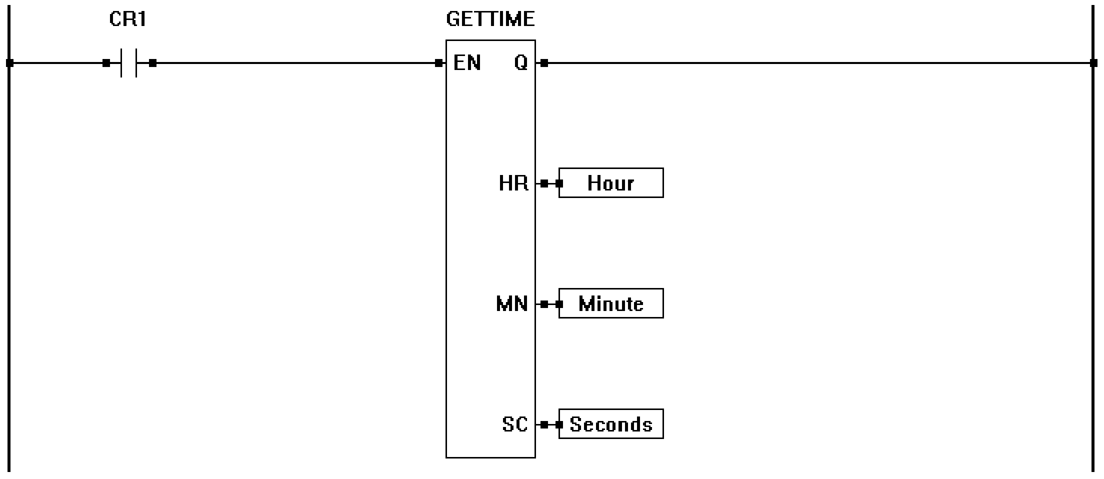
The Q output is true when the function is enabled. The HR output returns the hour of the day (0-23) , the MN output returns the minutes and the SC returns the seconds. The HR, MN and SEC outputs must be connected to Integer variables.

Input / Output Connections:

The GETTIME function block placement requires connections of one input pin (EN) and four output pins (Q, HR, MN, SEC).

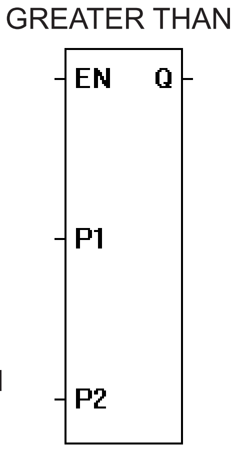
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State
EN	Input			X		Active True
Q	Output			X		
HR	Output	X				
MN	Output	X				
SC	Output	X				

Example Circuit:



Related Functions: GETDATE, SETTIME, SETDATE

GREATER THAN (>)



Description:

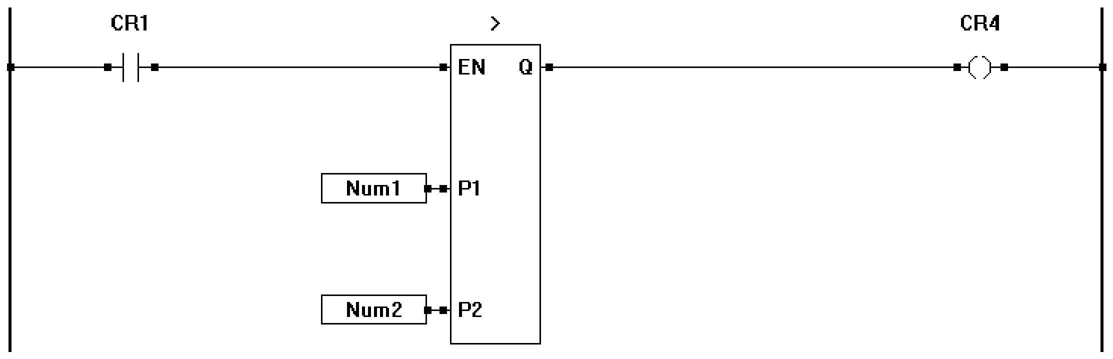
The GREATER THAN provides an if greater than comparison for the P*x* inputs. The number of inputs is specified when the object is placed. The output (Q) is true if P1 is greater than P2 and P2 is greater than P3 and so on. The enable (EN) must be true for the GREATER THAN function to be enabled.

Input / Output Connections:

The GREATER THAN function block placement requires connections of at least 3 input pins (EN, P1, P2) and one output pin (Q). The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P*x*	Input	X	X				Number of inputs is dynamic
Q	Output			X			

Example Circuit:

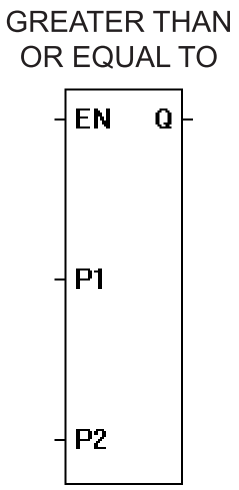


Related Functions: >, <, <=, <>, =

GREATER THAN OR EQUAL TO (>=)

Description:

The GREATER THAN OR EQUAL TO provides an if greater than or equal to comparison for the Px inputs. The number of inputs is specified when the object is placed. The output (Q) is true if P1 is greater than or equal to P2 and P2 is greater than or equal to P3 and so on. The enable (EN) must be true for the GREATER THAN OR EQUAL TO function to be enabled.

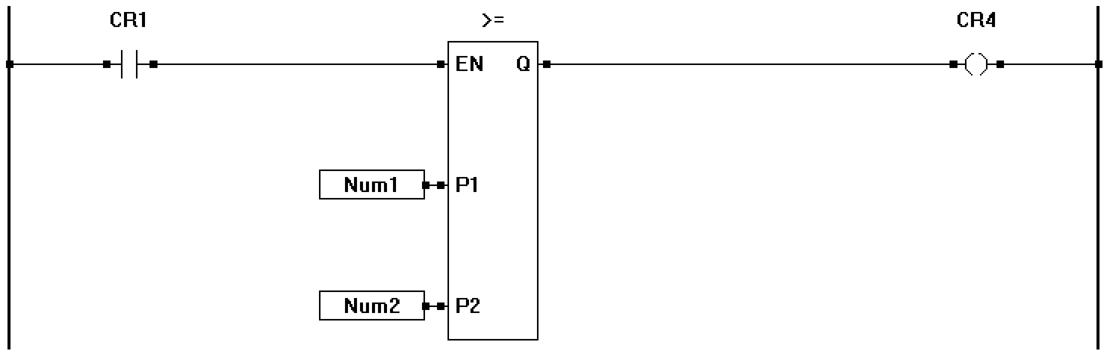


Input / Output Connections:

The GREATER THAN OR EQUAL TO function block placement requires connections of at least 3 input pins (EN, P1, P2) and one output pin (Q). The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

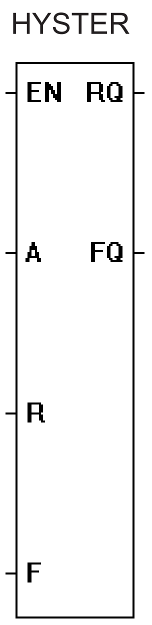
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P*x*	Input	X	X				Number of inputs is dynamic
Q	Output			X			

Example Circuit:



Related Functions: >, < , <=, <>, =

HYSTER



Description:

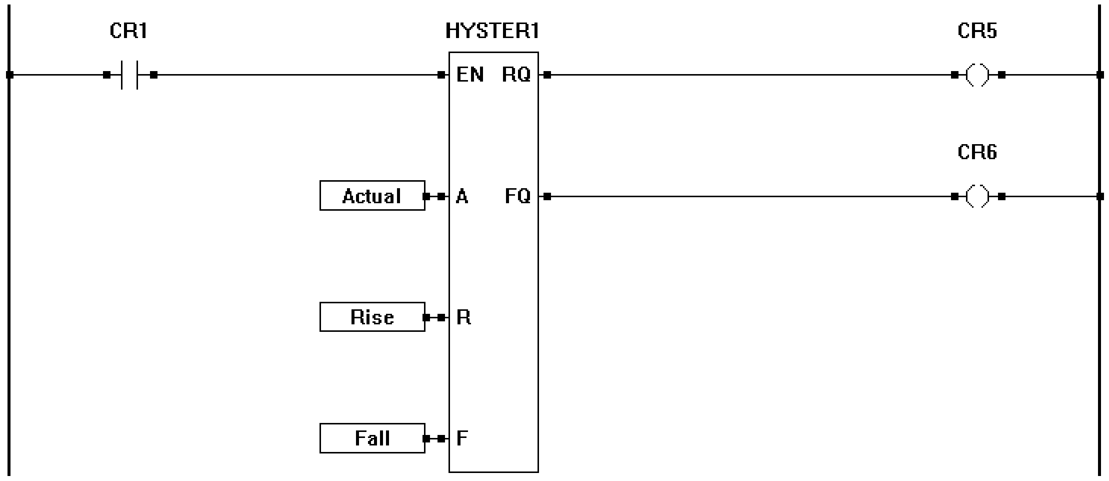
The HYSTER provides hysteresis into a control loop. When the actual (A) is greater than the rise (R), then output RQ is true and FQ is false. When actual (A) is less than fall (F), the output FQ is true and RQ is false. The enable (EN) must be true for the HYSTER function to be enabled.

Input / Output Connections:

The HYSTER function block placement requires connections of four input pins (EN, A, R, F) and two output pins (RQ, FQ).

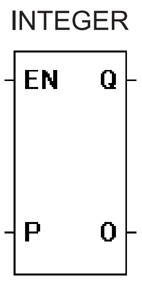
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
A	Input		X				
R	Input		X				
F	Input		X				
RQ	Output			X			
FQ	Output			X			

Example Circuit:



Related Functions: LIMIT

INTEGER



Description:

The INTEGER function converts the input (P) into an integer output (O). The enable (EN) must be true for the INTEGER function to be enabled. The Q output is true when the INTEGER function is enabled.

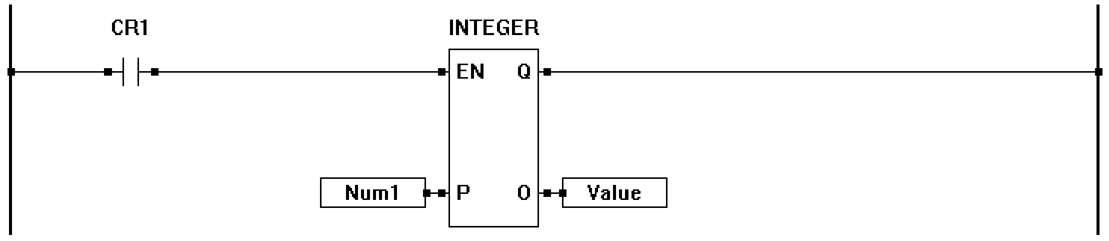
In addition to converting a Boolean, Timer or Real to an integer, the INTEGER function block can be used to copy one integer to another.

Input / Output Connections:

The INTEGER function block placement requires connections of two input pins (EN, P) and two output pins (Q, O).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P	Input	X	X	X	X		
O		X					
Q	Output			X			

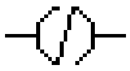
Example Circuit:



Related Functions: REAL, BOOLEAN, TIMER

INVERTED COIL

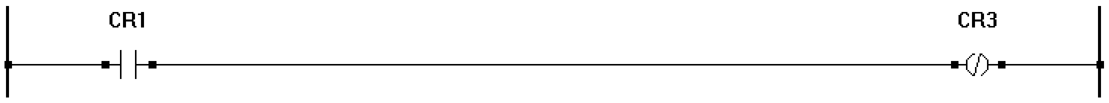
INVERTED COIL



Description:

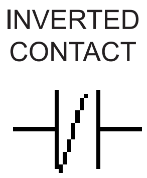
The INVERTED COIL is a representation of an internal boolean variable output (coil) or an actual hardware (real world) output. Its normal state is true or normally energized. An internal INVERTED COIL may also be referred to as a *control relay* (CR). If there is *power flow* to the INVERTED COIL, then it will be false (off). If there is no *power flow* to the INVERTED COIL, then it will be true (on). The INVERTED COIL may only be placed in the last column.

Example Circuit:



Related Functions: DIRECT COIL, DIRECT CONTACT, INVERTED CONTACT

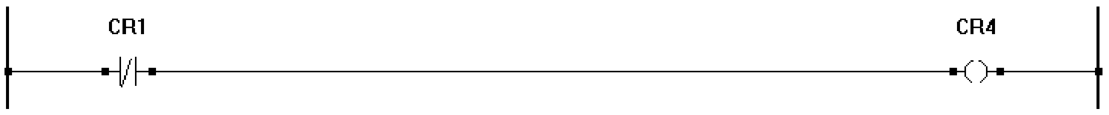
INVERTED CONTACT



Description:

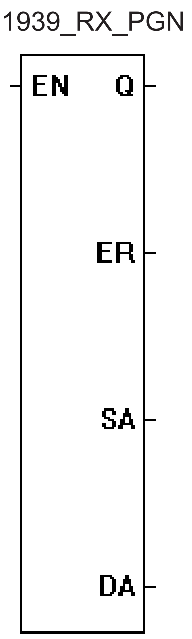
The INVERTED CONTACT is a representation of an internal boolean variable input or an actual hardware (real world) input. Its normal state is true or normally energized. An internal INVERTED CONTACT may also be referred to as a *control relay* (CR). A false condition on the input (if internal coil is true for internal contacts or real world input is false), then the contact will allow *power flow* and devices located to the right of the DIRECT CONTACT may operate. A true on it's coil or real world input will result in it's contacts to not allow *power flow*.

Example Circuit:



Related Functions: DIRECT CONTACT, DIRECT COIL, INVERTED COIL

J1939_RX_PGN



Description:

The J1939_RX_PGN function block is used to receive data over the J1939 / NMEA 2000 CAN network. There are several configurable items for receiving data, refer to **Chapter 14 - CAN Networking (J1939/NMEA 2000).**

The J1939_RX_PGN function block receives data and stores it in variables located in the ladder diagram program. These variables are mapped when the J1939_RX_PGN function block is placed. Each function block insertion (instance) is treated individually in the ladder diagram program.

Input / Output Connections:

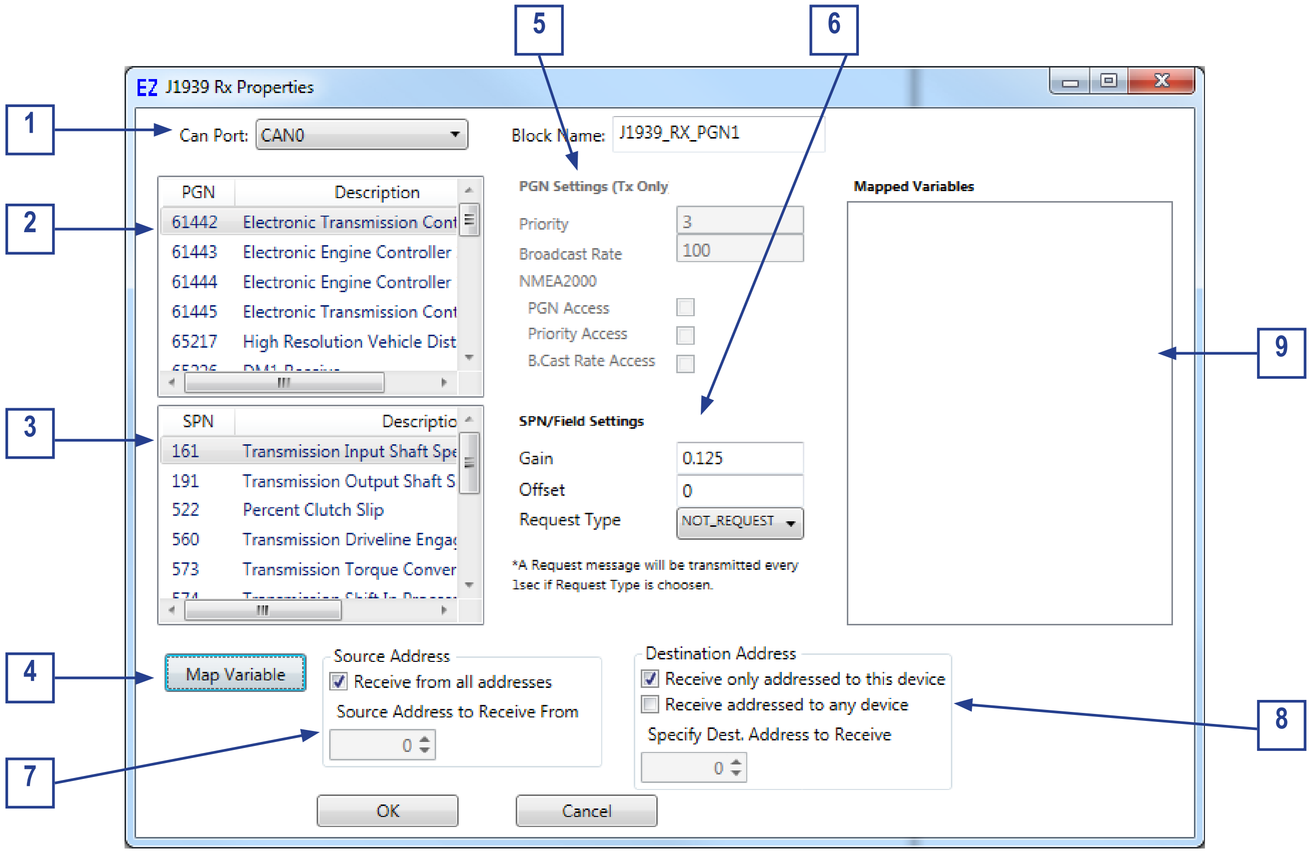
When the **EN** (ENABLE) is true, the function block is active and will receive J1939/NMEA 2000 data as configured. The data is stored in the mapped variables.

The **Q** Output is true for one ladder diagram scan when data is received.

The **ER** (ERROR) output stores the current status of the data received from the PGN.

The **SA** is the Source Address output. It must be connected to an integer variable. This variable will store the Source Address of the last receive (which address this PGN was received from).

The **DA** is the Destination Address output. It must be connected to an integer variable. This variable will store the Destination Address of the last receive if the PGN had a specific destination in the broadcast packet. If the broadcast was a global broadcast, then the DA does not apply.



Can Port: CAN0

Block Name: J1939_RX_PGN1

PGN	Description
61442	Electronic Transmission Cont
61443	Electronic Engine Controller
61444	Electronic Engine Controller
61445	Electronic Transmission Cont
65217	High Resolution Vehicle Dist

SPN	Descriptio
161	Transmission Input Shaft Spe
191	Transmission Output Shaft S
522	Percent Clutch Slip
560	Transmission Driveline Engag
573	Transmission Torque Conver

PGN Settings (Tx Only

Priority 3

Broadcast Rate 100

NMEA2000

PGN Access ☐

Priority Access ☐

B.Cast Rate Access ☐

SPN/Field Settings

Gain 0.125

Offset 0

Request Type NOT_REQUEST

*A Request message will be transmitted every 1sec if Request Type is choosen.

Mapped Variables

Source Address

☑ Receive from all addresses

Source Address to Receive From 0

Destination Address

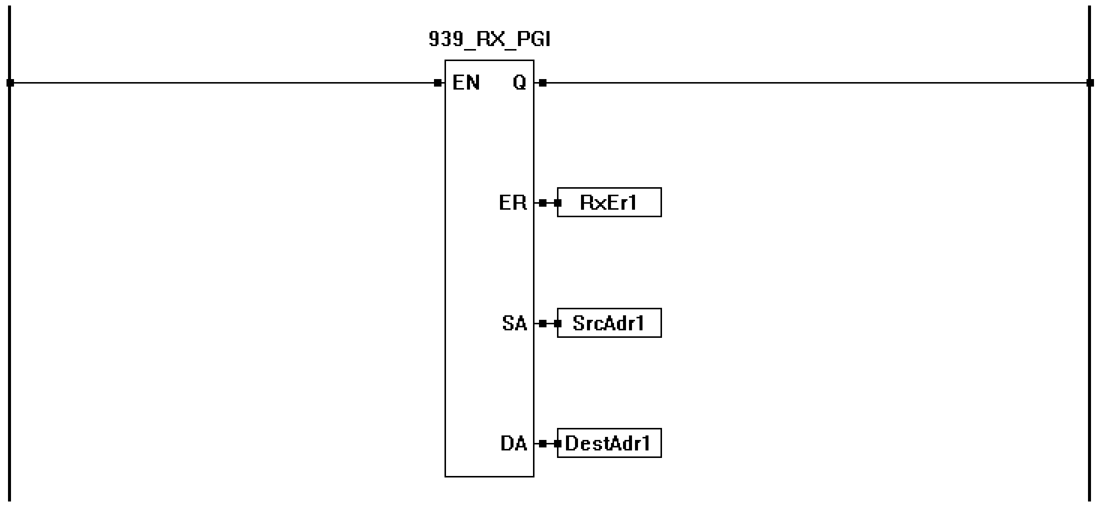
☑ Receive only addressed to this device

☐ Receive addressed to any device

Specify Dest. Address to Receive 0

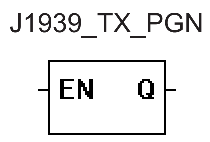
1. CAN Port Select	Drop down box to select the CAN port (network) to be used for this J1939 receive function block.
2. PGN Pane	Select the PGN to receive with this receive function block. Only one PGN per function block is allowed.
3. SPN Pane	Select the SPN(s) to receive and store in variables of the selected PGN.
4. Map Variable Button	Clicking this button opens the map variable dialog to map the selected SPN data to variables. The data variable is required, but the status variable is optional. Double-c licking the SPN in the SPN pane will also open the map variable dialog.
5. PGN Settings	The PGN settings will update as different PGNs are selected. These values are based on the PGN settings in the J1939 database.
6. SPN /Field Settings	The SPN settings will update as different SPNs are selected. These values are based on the SPN settings in the J1939 database. The Gain and Offset may be overridden by entering new values. Values changed will only affect this function block, not the J1939 database. The Request Type may be configured to NOT_REQUEST which is standard or J1939_REQUEST to request a PGN/SPN on J1939 or NMEA_REQUEST to request data on an NMEA 2000 network.
7. Source Address Area	This area determines the allowed source address of the network to receive data from (allowed device ID). Data may be received from all addresses or from specific address.
8. Destination Address Area	This area determines the allowed destination addresses (in the broadcast packet) from which to receive data. Optionally, the receive function block can receive data that is specifically addressed to this device (controller), transmitted to any device or transmitted specifically to a device (but not this one). This allows to receive data that is specifcally transmitted to another device on the network.
9. Mapped Variables Area	As variables are mapped to SPNs, they will be listed in this area.

Example Circuit:



Related Functions: J1939_TX_PGN

J1939_TX_PGN



Description:

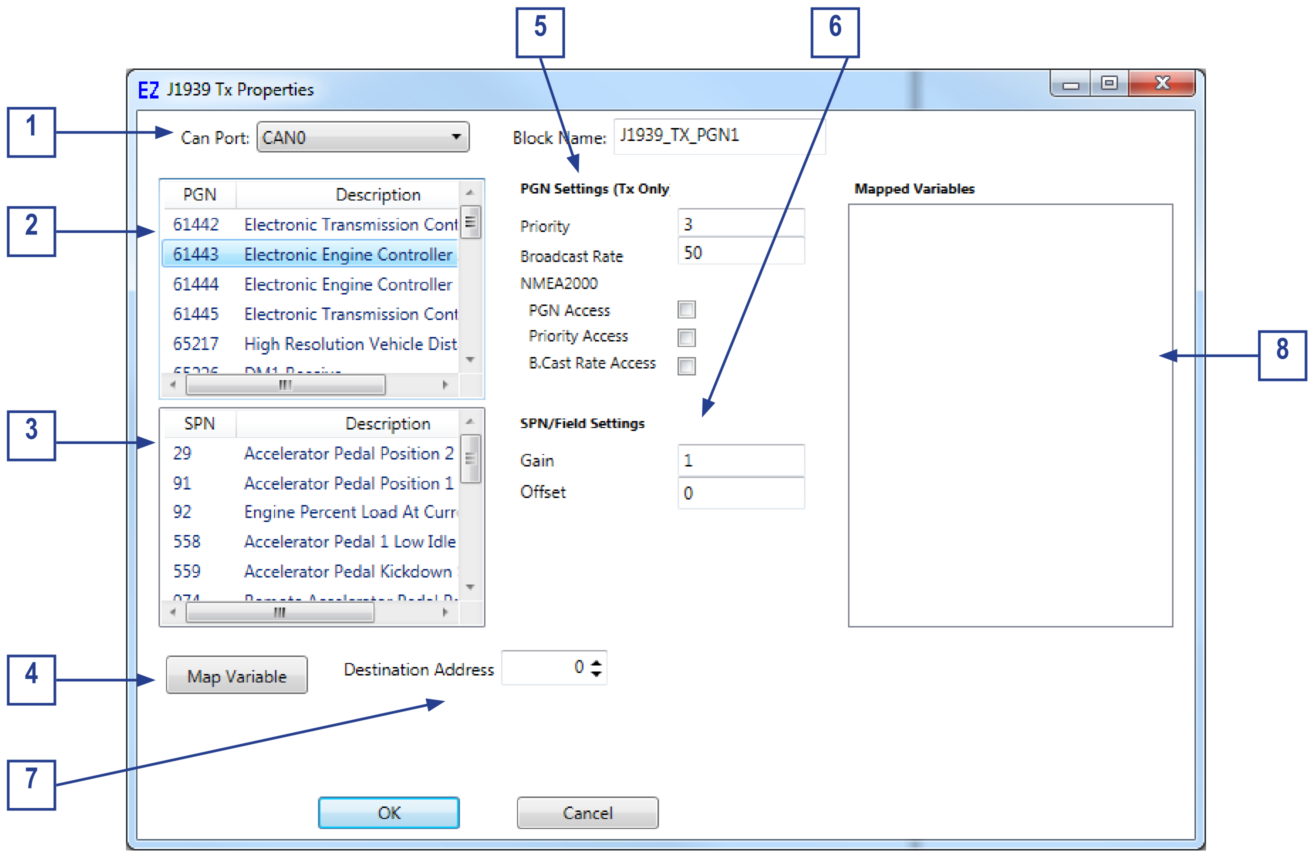
The J1939_TX_PGN function block is used to transmit / broadcast data over the J1939 / NMEA 2000 CAN network. There are several configurable items for transmitting data, refer to **Chapter 14 - CAN Networking (J1939/NMEA 2000).**

The J1939_TX_PGN function block transmits data that is stored in variables located in the ladder diagram program. These variables are mapped when the J1939_TX_PGN function block is placed. Each function block insertion (instance) is treated individually in the ladder diagram program.

Input / Output Connections:

When the **EN** (ENABLE) is true, the function block is active and will transmit J1939/NMEA 2000 data as configured (based on broadcast rates). The transmitted data is read from the mapped variables.

The **Q** Output is true when the EN is true.



Can Port: CAN0

Block Name: J1939_TX_PGN1

PGN	Description
61442	Electronic Transmission Cont
61443	Electronic Engine Controller
61444	Electronic Engine Controller
61445	Electronic Transmission Cont
65217	High Resolution Vehicle Dist

SPN	Description
29	Accelerator Pedal Position 2
91	Accelerator Pedal Position 1
92	Engine Percent Load At Curr
558	Accelerator Pedal 1 Low Idle
559	Accelerator Pedal Kickdown

PGN Settings (Tx Only

Priority 3

Broadcast Rate 50

NMEA2000

PGN Access ☐

Priority Access ☐

B.Cast Rate Access ☐

SPN/Field Settings

Gain 1

Offset 0

Mapped Variables

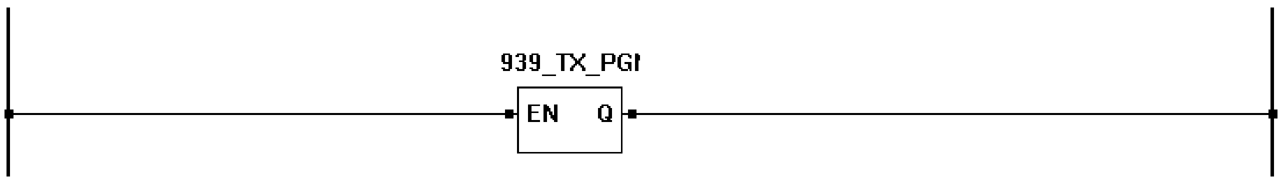
Destination Address 0

1. CAN Port Select Drop down box to select the CAN port (network) to be used for this J1939 transmit function block.

2. PGN Pane Select the PGN to transmit with this receive function block. Only one PGN per function block is allowed.

3. SPN Pane	Select the SPN(s) to transmit from variables as the selected PGN / SPN.
4. Map Variable Button	Clicking this button opens the map variable dialog to map the selected SPN to variables storing the data. Double-clicking the SPN in the SPN pane will also open the map variable dialog.
5. PGN Settings	The PGN settings will update as different PGNs are selected. These values are based on the PGN settings in the J1939 database. The Priority and Broadcast rate can be overridden by entering new values. Values changed will only affect this function block, not the J1939 database. For NMEA 2000, optional checkboxes determine specific parameters for NMEA 2000. Refer to the NMEA 2000 specification for details.
6. SPN /Field Settings	The SPN settings will update as different SPNs are selected. These values are based on the SPN settings in the J1939 database. The Gain and Offset may be overridden by entering new values. Values changed will only affect this function block not the J1939 database.
7. Destination Address Area	This area determines the destination address (in the broadcast packet) to send data to. If the destination address is set to 255, then the broadcast will be global. If set to a number other than 255, it is specifically addressed to that ID. The availability of setting the destination address depends on the PGN/SPN selected. Global may the only type supported based on the actual PGN/SPN.
8. Mapped Variables Area	As variables are mapped to SPNs, they will be listed in this area.

Example Circuit:



Related Functions: J1939_RX_PGN

JMP

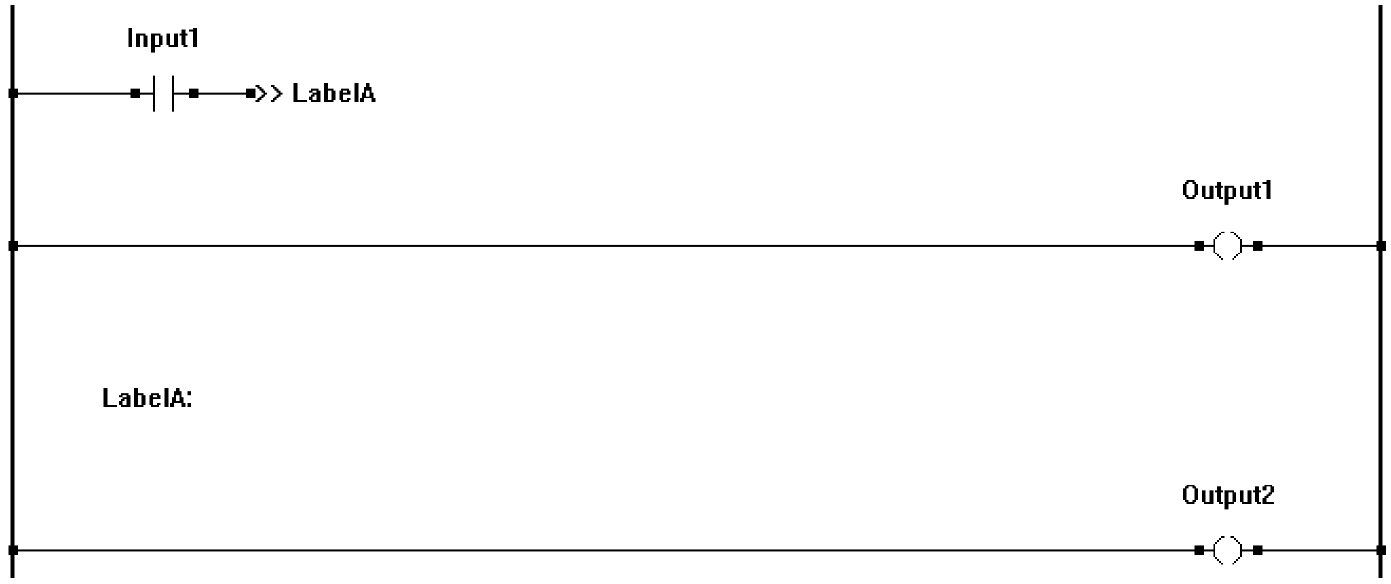
Description:

The JMP function allows sections of ladder to be skipped by "jumping" to another section. A LABEL must first be placed before the JMP is inserted. When the condition is true to trigger the jump, the program scan jumps to the label, skipping any ladder between the jump and label.

Input / Output Connections:

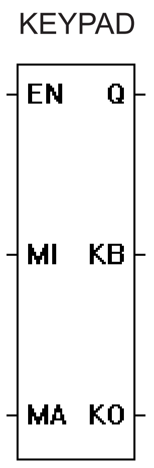
There are no Input or Output Connections

Example Circuit:



Related Functions: LABEL

KEYPAD



Description:

The KEYPAD function is used to allow users to input data. This function requires the Keypad feature be installed on the target's hardware and target settings.

The keypad may be used in two ways. The first is using the KEYPAD function. This is useful for allowing a user to input numeric data. The second is reading individual button presses as a digital input. This is useful for menus. **See Chapter 10 - Keypad Support** for details on keypad use.

Using the KEYPAD for Numeric Input (Keypad Function Block)

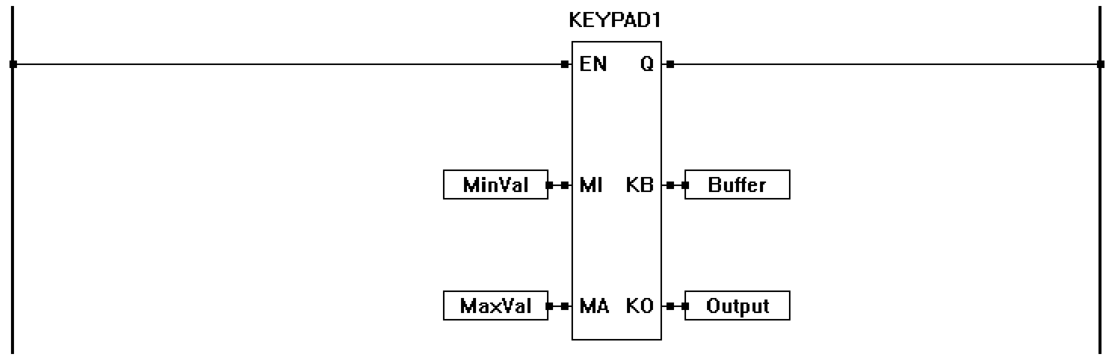
When EN is true, the function is enabled. Data is entered using numeric keypad buttons. These numeric buttons are temporarily stored in the keypad buffer KB. When **ENTER** is pressed, the KB is transferred stored in the variable connected to the output (KO). The output Q is true for the ladder diagram scan in which the **ENTER** was pressed. Pressing the clear button on the keypad erases the buffer (KB). The MI input specifies the minimum value allowed to be entered on the keypad while the MA input specifies the maximum value allow to be entered on the keypad.

Input / Output Connections:

The KEYPAD function block placement requires connections of three input pins (EN, MI, MA) and three output pins (Q, KB, KO).

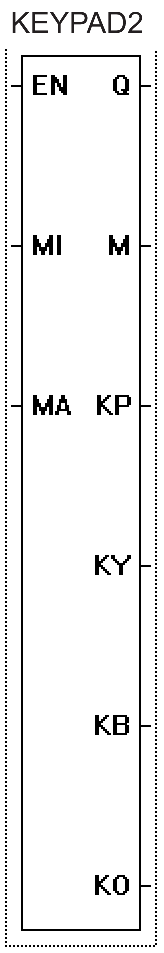
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
MI	Input	X	X				Minimum Allowed Value
MA	Input	X	X				Maximum Allowed Value
KB	Output	X	X				Keypad Buffer
KO	Output	X	X				Keypad Entered Value
Q	Output			X			

Example Circuit:



Related Functions: KEYPAD2

KEYPAD2



Description:

The KEYPAD2 function is used to allow users to input data. It operates similar to the KEYPAD function. This function requires the Keypad feature be installed on the target's hardware and target settings. **See Chapter 10 - Keypad Support** for details on keypad use.

The Keypad2 function block provides additional features over the Keypad function block. These featues allow menus and Discrete key press menu items to be combined, allowing for a more powerful and easier to implement menu.

Using the KEYPAD for Numeric Input (Keypad2 Function Block)

When EN is true, the function is enabled. Data is entered using numeric keypad buttons. These numeric buttons are temporarily stored in the keypad buffer KB. When **ENTER** is pressed, the KB is transferred stored in the variable connected to the output (KO). The output Q is true for the ladder diagram scan in which the **ENTER** was pressed. Pressing the clear button on the keypad erases the buffer (KB). The MI input specifies the minimum value allowed to be entered on the keypad while the MA input specifies the maximum value allow to be entered on the keypad.

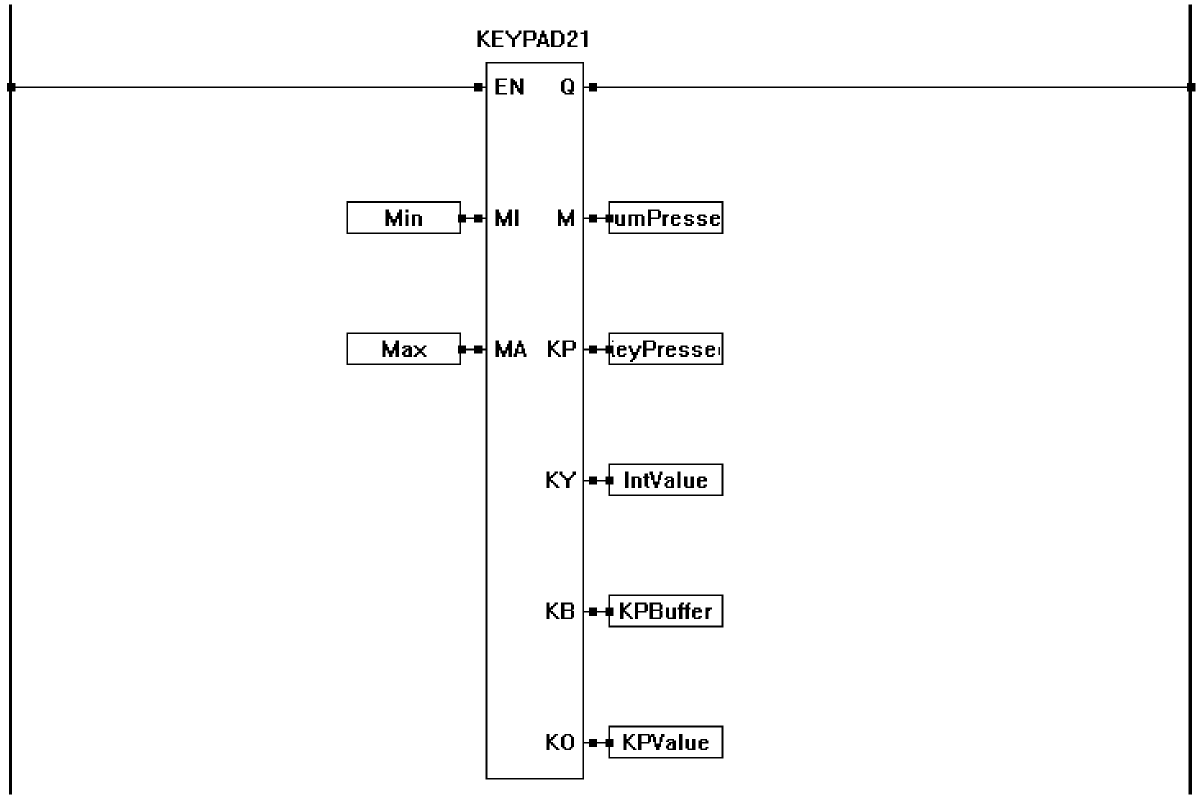
The M output is a boolean that is set to true when any number (0-9), + or . is pressed. Pressing the **ENTER** or **CLEAR** will reset the M output to false. The KP output is a boolean output that is true only for the single scan that a key was pressed. The KY output is an integer output of the actual ASCII value of the key that was pressed.

Input / Output Connections:

The KEYPAD2 function block placement requires connections of three input pins (EN, MI, MA) and six output pins (Q, KB, KO, M, KY, KP).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
MI	Input	X	X				Minimum Allowed Value
MA	Input	X	X				Maximum Allowed Value
KB	Output	X	X				Keypad Buffer
KO	Output	X	X				Keypad Entered Value
M	Output			X			True when 0-9, + or - Pressed
KY	Output	X					Integer Output of Ascii Value Pressed
KP	Output			X		True One Scan	True one scan when key is pressed
Q	Output			X			

Example Circuit:



Related Functions: KEYPAD

LABEL

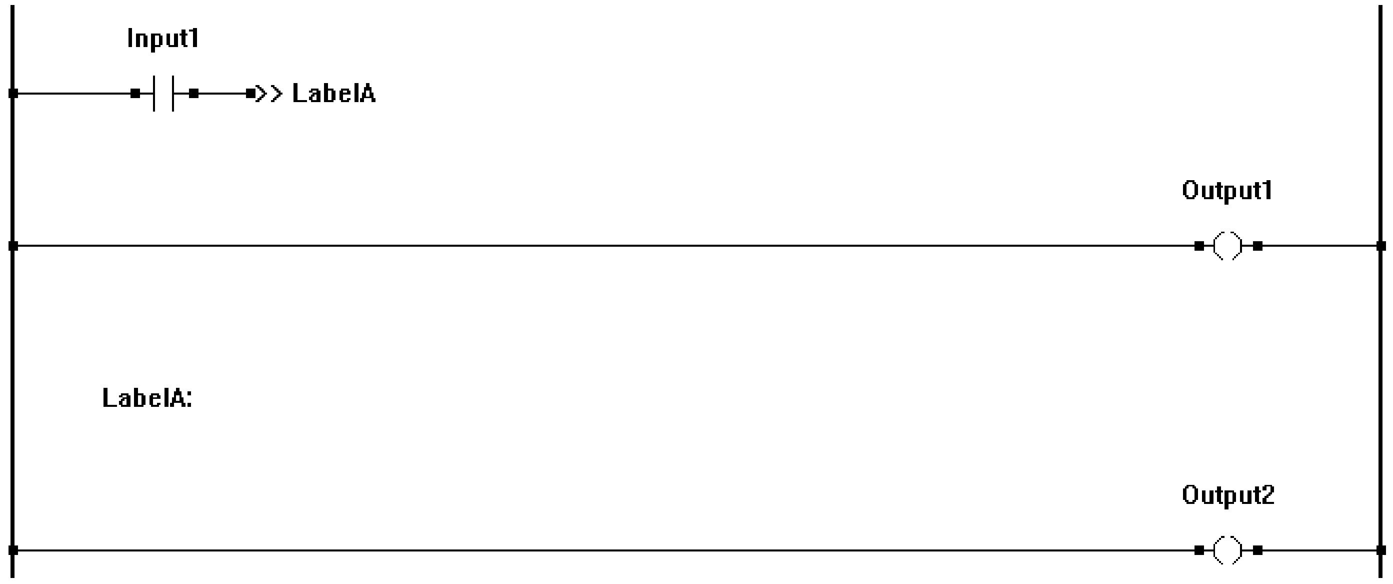
Description:

The LABEL function works with the JMP function to skip ladder diagram sections. A LABEL must be placed first, then the JMP inserted. When the condition is true to trigger the jump, the program scan "jumps" to the LABEL, skipping any ladder between the jump and label.

Input / Output Connections:

There are no Input or Output Connections

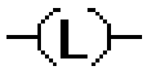
Example Circuit:



Related Functions: JMP

LATCH (COIL)

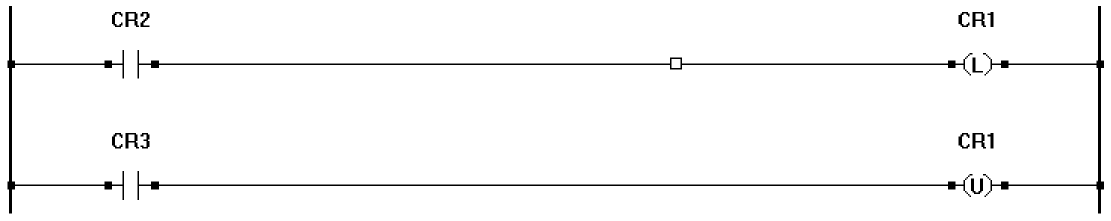
LATCH COIL



Description:

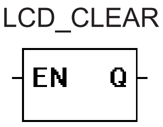
The LATCH coil operates similar to the DIRECT COIL except when true (energized), it will remain energized until a true is seen on the UNLATCH coil. LATCH and UNLATCH coils work as pairs. Any boolean variable can be used as a LATCH / UNLATCH coil.

Example Circuit:



Related Functions: UNLATCH, DIRECT COIL, INVERTED COIL

LCD_CLEAR



Description:

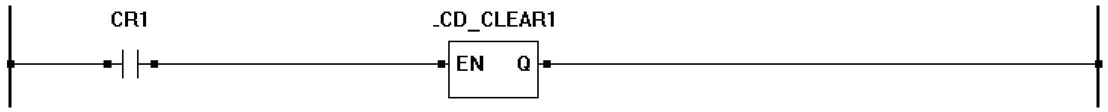
The LCD_CLR function block is used to clear the LCD display. When the EN input detects a rising edge, the LCD Display is set to be cleared. The LCD display is cleared and updated at the END of the ladder scan.

Input / Output Connections:

The LCD_CLR function block placement requires connections of one input pin (EN) and one output pin (Q).

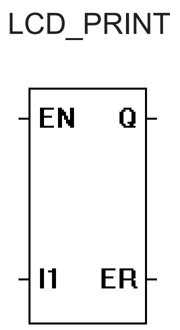
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Rising Edge	
Q	Output			X			

Example Circuit:



Related Functions: LCD_PRINT

LCD_PRINT



Description:

The LCD_PRINT function is used for printing data to the LCD Display.

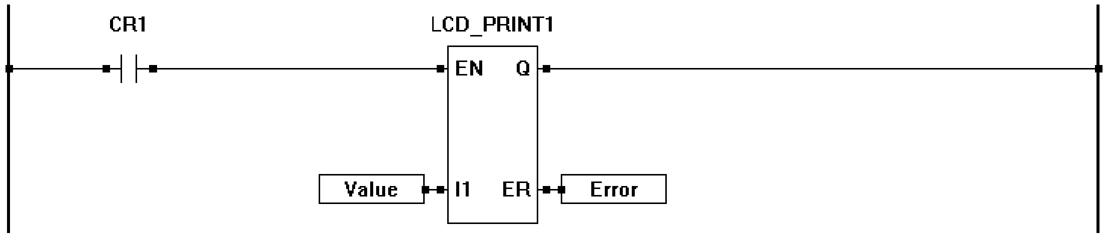
When then EN input senses a rising edge, the block prepares the text that was provided when the LCD_PRINT function was placed and marks it to update at the end of the current ladder scan. The Q output is set true when the print is completed. The ER output is set to non-zero if the printed data is larger than the LCD will display. At the end of the ladder scan, the display is updated. See **Chapter 9 - LCD Display Support**.

Input / Output Connections:

The LCD_PRINT function block placement requires connections of at least one input pin (EN) and two output pins (Q, ER). Additional inputs are based on variables in printing text.

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Rising Edge	
ERR	Output	X					Set to non-zero if error
I*x*	Input	X	X	X			Dynamic Inputs
Q	Output			X			True when print is completed

Example Circuit:



Text / Message Formatting:

The LCD_PRINT function text formatted per ANSI C "printf". Variables as well as text may be printed. These variables must be formatted correctly. As variables are added to the *text,* the function block will automatically add the appropriate input for the variables.

Text

Text is entered exactly as the message is intended.

Printing text longer than the display will support will result in truncated printing. It is ideal to structure printing based on column and row and to verify length of the printing.

Variables

Variables are placed in the text using flags and print specification fields. The following is the configuration for adding variables to the text.

%*flag* width .precision   Example Text: OIL PSI %-3d

% - identifies the beginning of a variable or other type of text entry
flag - This flag is optional. Use the following flags to change the way data is transmitted.

Flag	Description
-	Left align the variable within the specified *width*. Default is align right.
0	If width is prefixed with 0, leading zeros are added until the minimum width is reached. If 0 and - are used together, the 0 is ignored. If 0 is specified in an integer format, the 0 is ignored.
width -	This flag is optional. Width is the number of characters that will be printed (total).
.precision -	This flag is optional. The precision is the number of digits after the decimal point when using REAL variables.

Variable Formats

Variables are formatted based on the variable type. The following are supported variable types and their format.

%d	Signed Integer	%X	Upper Case Hexadecimal
%u	Unsigned Integer	%f	Real or Float Variable
%x	Lower Case Hexadecimal	%b	binary
%o	Octal		

Other Special Characters and Formats

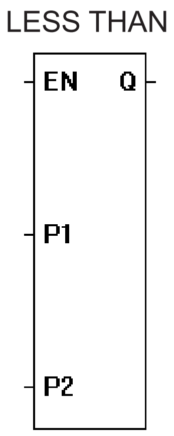
To Print	Use	To Print	Use
%	%%	OFF / ON	%O
Boolean 0 or 1	%d	FALSE / TRUE	%T

Examples:

Format	Result	Format	Result
OIL: %d	OIL: 25	OIL: %04d	OIL: 0025
LS1: %T	LS1: TRUE	LS1: %O	LS1: OFF
TEMP: %6.2f	TEMP: 234.12	TEMP: %3.f	TEMP: 234

Related Functions: LCD_CLEAR

LESS THAN (<)



Description:

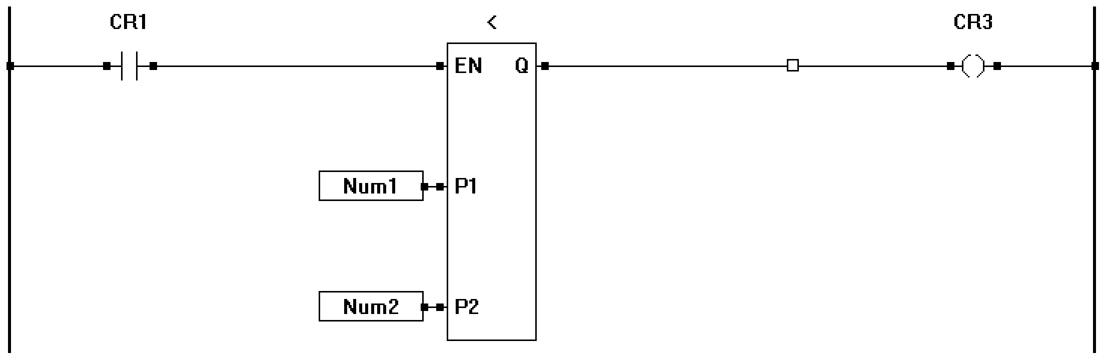
The LESS THAN provides an if less than comparison for the P*x* inputs. The number of inputs is specified when the object is placed. The output (Q) is true if P1 is less than P2 and P2 is less than P3 and so on. The enable (EN) must be true for the LESS THAN function to be enabled.

Input / Output Connections:

The LESS THAN function block placement requires connections of at least 3 input pins (EN, P1, P2) and one output pin (Q). The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

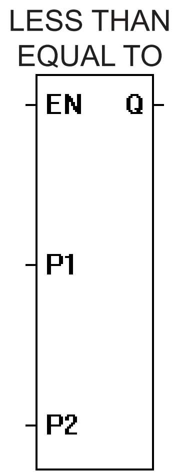
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P*x*	Input	X	X				Number of inputs is dynamic
Q	Output			X			

Example Circuit:



Related Functions: <=, >, >=, <>, =

LESS THAN OR EQUAL TO (=<)



Description:

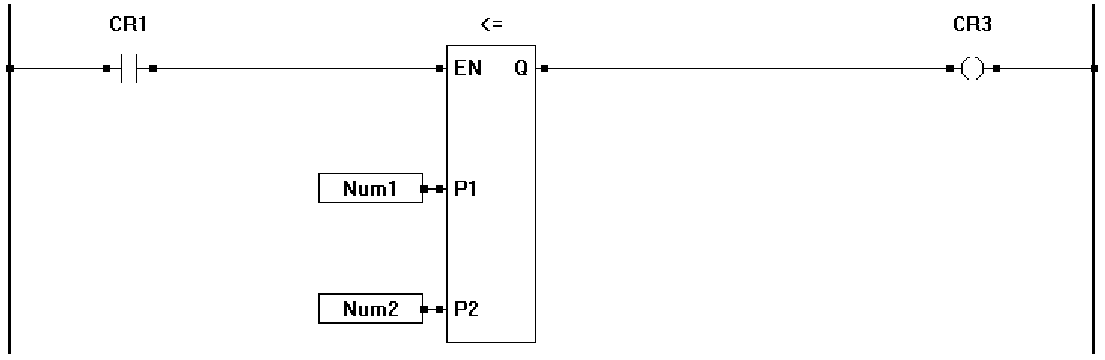
The LESS THAN or EQUAL TO provides an if less than or equal to comparison for the P*x* inputs. The number of inputs is specified when the object is placed. The output (Q) is true if P1 is less than or equal to P2 and P2 is less than or equal to P3 and so on. The enable (EN) must be true for the LESS THAN or EQUAL TO function to be enabled.

Input / Output Connections:

The LESS THAN or EQUAL TO function block placement requires connections of at least 3 input pins (EN, P1, P2) and one output pin (Q). The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

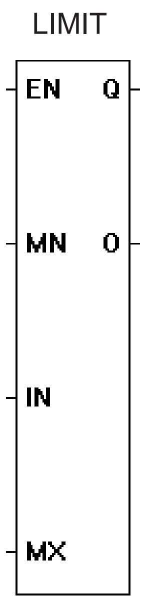
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P*x*	Input	X	X				Number of inputs is dynamic
Q	Output			X			

Example Circuit:



Related Functions: <, >, >=, <>, =

LIMIT



Description:

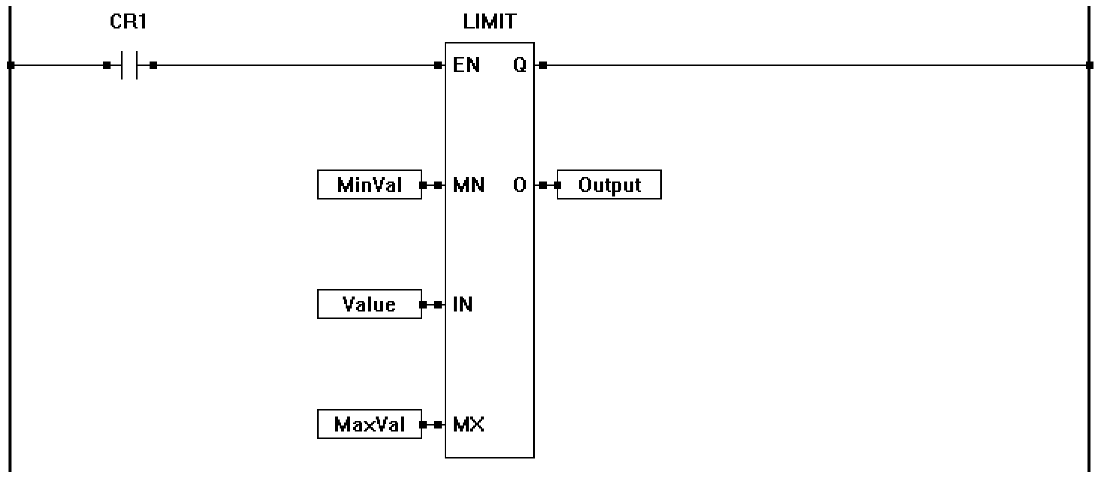
The LIMIT function provides minimum and maximum limited output for the input (IN). The function compares the input (IN). If it is greater that the maximum (MX), then the output (O) is equal to the maximum (MX). If it is less than the minimum (MN) then the output (O) is equal to the minimum (MN). If it is in between the maximum and minimum, then the output (O) is equal to the actual input (IN). The enable (EN) must be true for the LIMIT function to be enabled.

Input / Output Connections:

The LIMIT function block placement requires connections of four input pins (EN, MN, IN, MX) and two output pins (Q, O).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
MN	Input	X	X				
IN	Input	X	X				
MX	Input	X	X				
Q	Output			X			
O	Output	X	X				

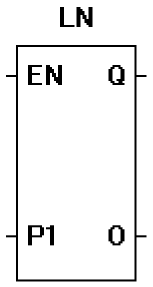
Example Circuit:



Related Functions: CMP, HYSTER

LN

Description:



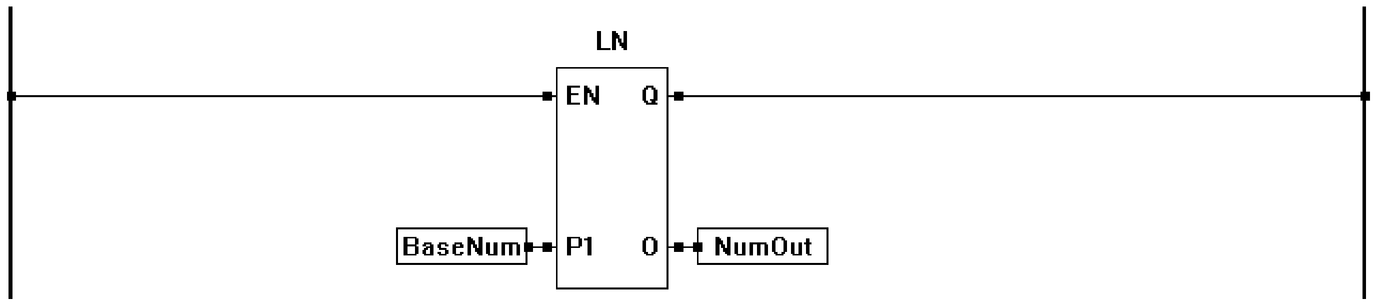
The LN function provides the natural logarithm of the P1 input. The output (O) is the natural logarithm of the P1 input. The enable (EN) must be true for the LN function to be enabled.

Input / Output Connections:

The LN function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

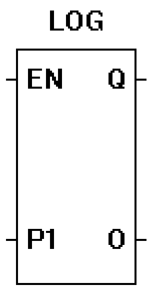
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X			
P1	Input		X				Base Number
O	Output		X				Natural Logarithm of P1 Base Number
Q	Output			X			

Example Circuit:



Related Functions: EXP, EXPT, SQRT, LOG

LOG

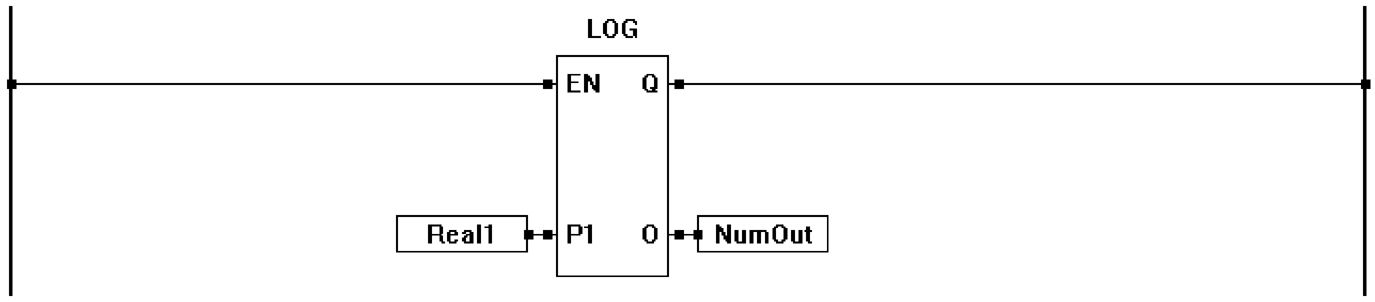


Description:
The LOG function calculates the logarithm (base 10) of the P1 input. The output (O) is the cacluated base 10 (logarithm) value of the P1 input. The enable (EN) must be true for the LOG function to be enabled.

Input / Output Connections:
The LOG function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

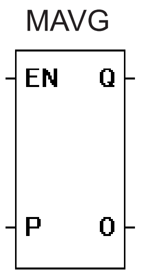
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X			
P1	Input		X				Base Number
O	Output		X				Logarithm of P1 Number
Q	Output			X			

Example Circuit:



Related Functions: EXP, EXPT, SQRT, LN

MAVG



Description:

The MAVG function calculates the moving average of the P input. The number of samples is specified when the object is placed. The output (O) is the calculated moving average value of the P input. The enable (EN) must be true for the MAVG function to be enabled. When EN is true, the output is the moving average. When EN is false, the output is equal to the P input.

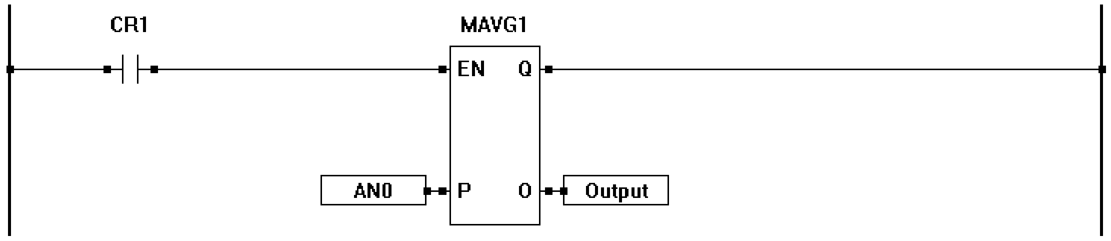
The larger the number of samples, the more RAM is used and the slower the reaction time of the block output to input changes. Size the number of samples to give the best suited reaction time and to use the least amount of RAM needed accomplish to meet the operation specifications.

Input / Output Connections:

The MAVG function block placement requires connections of two input pins (EN, P) and two output pins (Q, O).

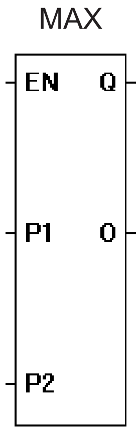
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P	Input	X	X				
O	Output	X	X				Moving Average of P
Q	Output			X			

Example Circuit:



Related Functions: AVG

MAX



Description:

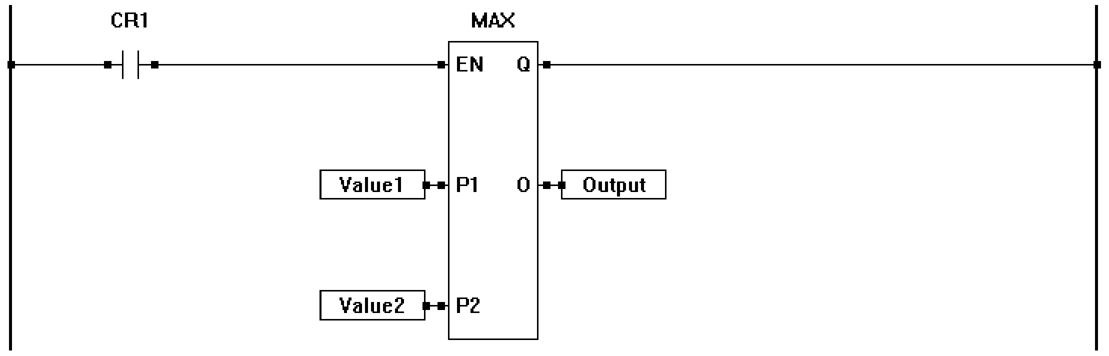
The MAX function compares all the Px input values and outputs the largest of them on the O Output. The number of inputs is specified when the object is placed. The enable (EN) must be true for the MAX function to be enabled.

Input / Output Connections:

The MAX function block placement requires connections of at least 3 input pins (EN, P1, P2) and two output pins (Q, O). The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

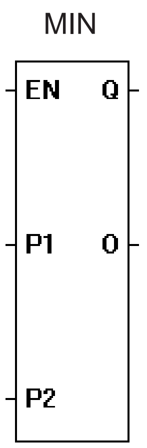
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P*x*	Input	X	X				Number of inputs is dynamic
O	Output	X	X				
Q	Output			X			

Example Circuit:



Related Functions: MIN

MIN



Description:

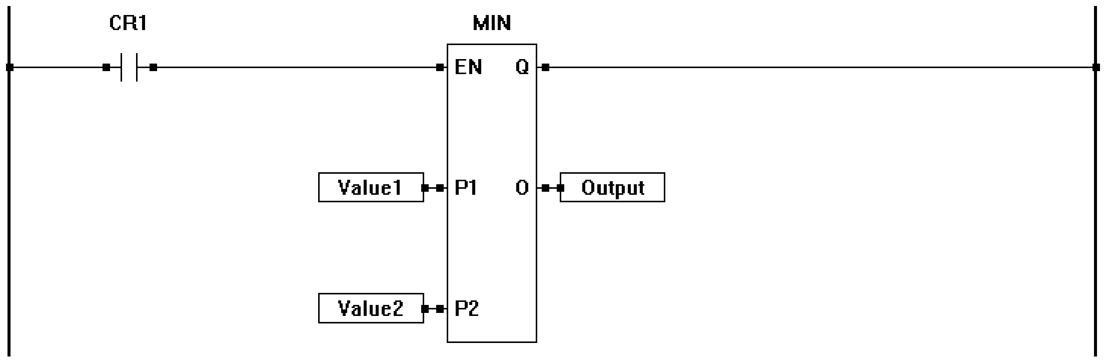
The MIN function compares all the Px input values and outputs the smalled of them on the O Output. The number of inputs is specified when the object is placed. The enable (EN) must be true for the MAX function to be enabled.

Input / Output Connections:

The MIN function block placement requires connections of at least 3 input pins (EN, P1, P2) and two output pins (Q, O). The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

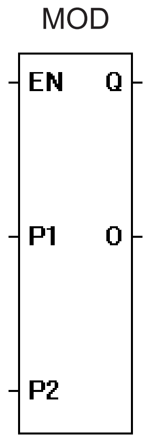
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P*x*	Input	X	X				Number of inputs is dynamic
O	Output	X	X				
Q	Output			X			

Example Circuit:



Related Functions: MAX

MOD



Description:

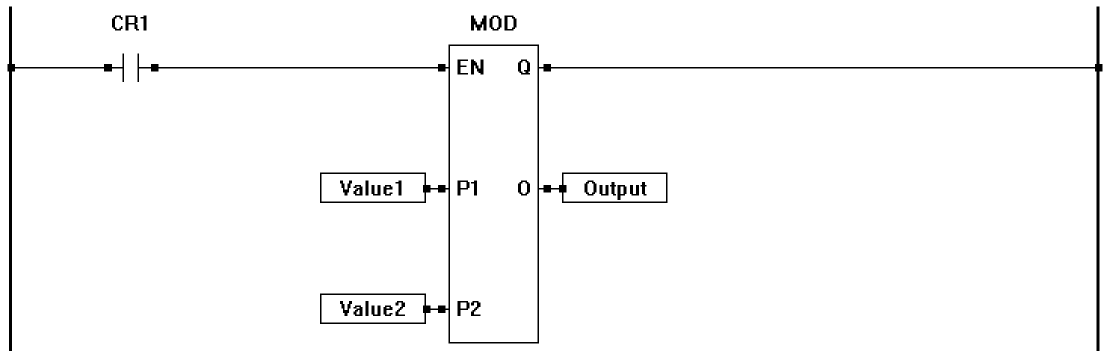
The MOD function calculates the modulo (remainder) of the division using the inputs P1 and P2. The P2 number should be greater than zero (zero or less than zero will cause the function to return invalid data the output). The enable (EN) must be true for the MOD function to be enabled.

Input / Output Connections:

The MOD function block placement requires connections of three input pins (EN, P1, P2) and two output pins (Q, O).

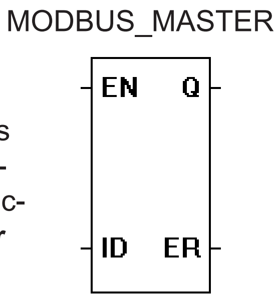
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X					Dividend
P2	Input	X					Divisor
O	Output	X					Remainder
Q	Output			X			

Example Circuit:



Related Functions: DIV

MODBUS_MASTER



Description:

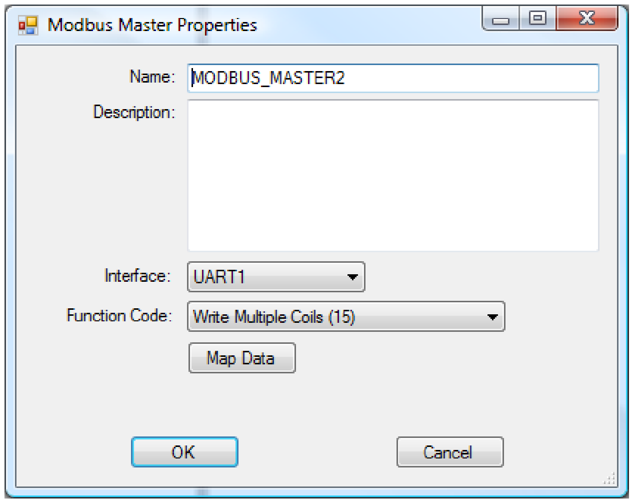
The MODBUS_MASTER function is used to communicate to slave devices on a Modbus Network. When the MODBUS_MASTER function is placed, additional information is provided that is required for communications including the interface (UART to use) and Function Code (Type of communication). For additional details and information, see **Chapter 13 - Modbus Networking.**

Input / Output Connections:

The MOD function block placement requires connections of three input pins (EN, P1, P2) and two output pins (Q, O).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
ID	Input	X					ID Number of Slave
ER	Output	X					Communication Status / Error Number
Q	Output			X			

MASTER Properties:



Name: MODBUS_MASTER2
Description:
Interface: UART1
Function Code: Write Multiple Coils (15)

The Modbus Master Properties Box shown left is automatically displayed when the MODBUS_MASTER function is placed in the ladder diagram.

Select the UART from the Interface Drop-down Box.

Select the Function Code from the Drop-down Box to identify the type of communication to the slave.

Click the Map Data button to map registers to variables during the communication process.

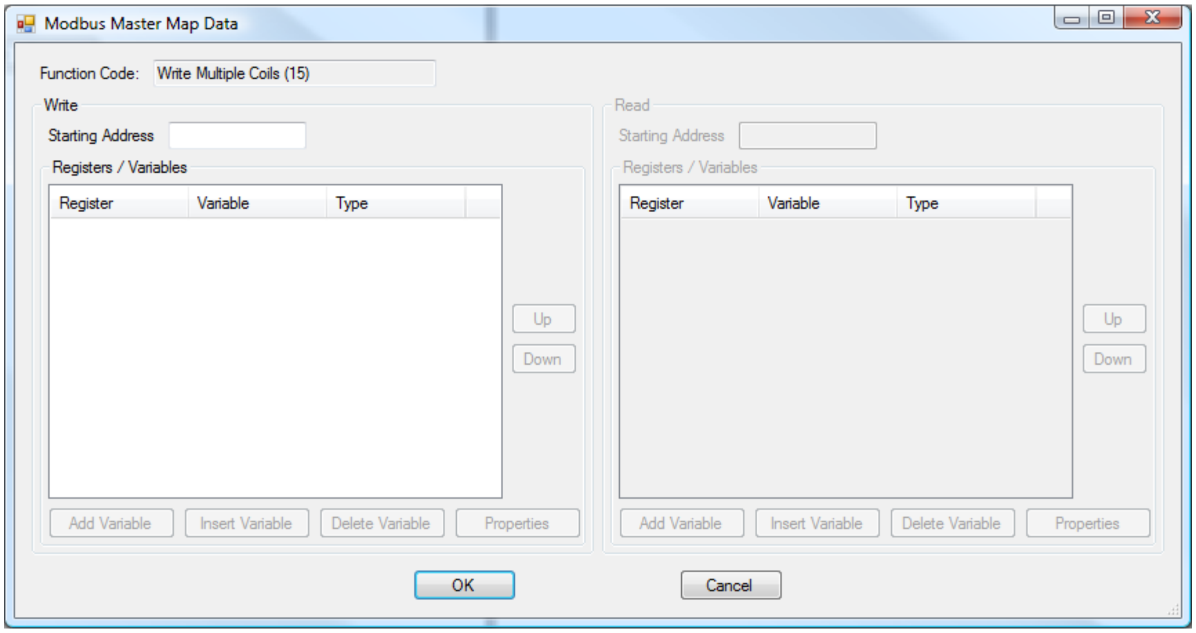
Supported Function Codes:

Read / Write Multiple Registers (23)
Write Multiple Registers (16)
Write Multiple Coils (15)
Read Input Registers (4)
Read Holding Registers (3)
Read Discrete Inputs (2)
Read Coils (1)

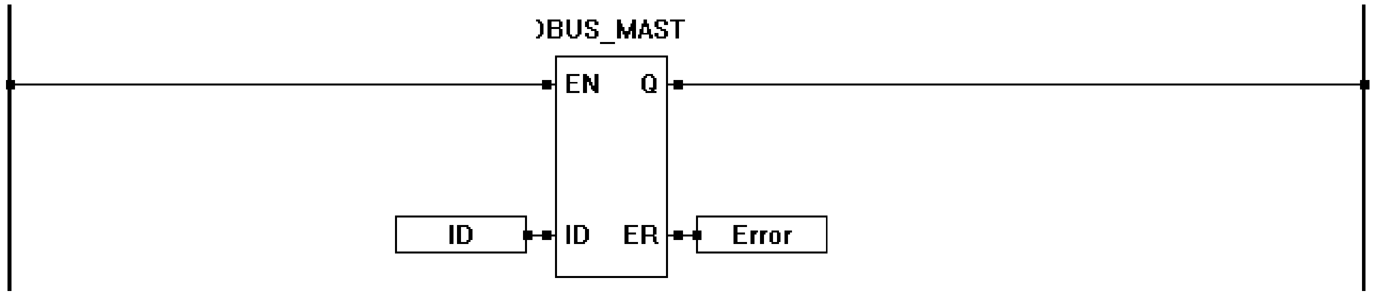
Map Data:

For the MODBUS_MASTER function block to read or write data (to/from slaves), variables and register assignments must be configured using the Map Data button. Using the Modbus Master Map Data window, variables may be assigned to transmit from and receive to. See window example shown.

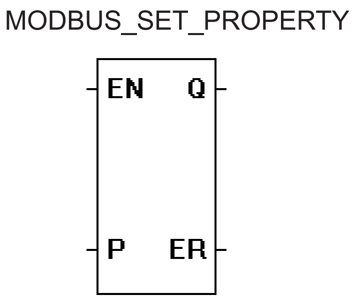
For additional details and information, see **Chapter 13 - Modbus Networking.**



Example Circuit:



MODBUS_SET_PROPERTY



Description:

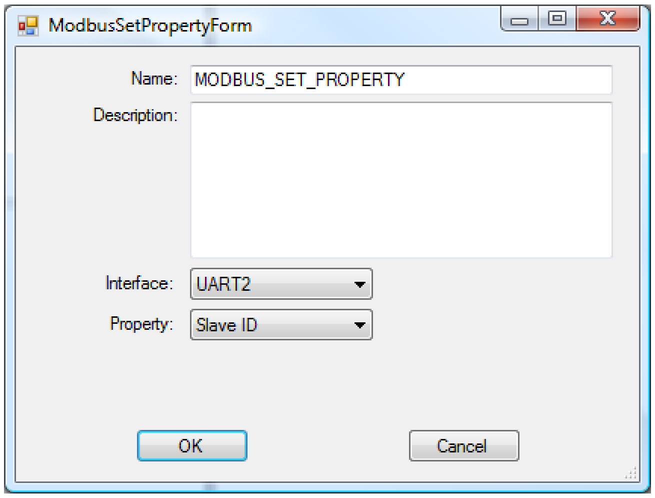
The MODBUS_SET_PROPERTY function is used to set or change the Modbus Slave ID for the target from the ladder diagram program. This feature is ideal for reading inputs (switches) and setting the slave ID accordingly. This function must be used to set the slave ID when using Modbus TCP and is optional for changing the slave ID for Modbus Slave using serial UARTS. For additional details and information, see **Chapter 13 - Modbus Networking.**

When the EN is true, the slave ID at input P is set for modbus functionality. The Q output is true when EN is true. The ERR output will identify if a error occurred (if other than zero).

Input / Output Connections:

The MODBUS_SET_PROPERTY function block placement requires connections of two input pins (EN, P) and two output pins (Q, ERR).

When placing the MODBUS_SET_PROPERTY function, an automatic dialog will appear that is used to set paramters such as the type of interface and the Property to be set. At this time, only the Slave ID is supported for the property.


ModbusSetPropertyForm

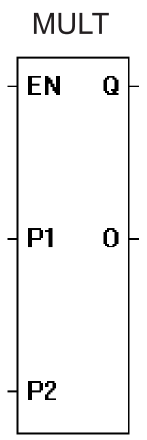
Name: MODBUS_SET_PROPERTY

Description:

Interface: UART2

Property: Slave ID

MULT



Description:

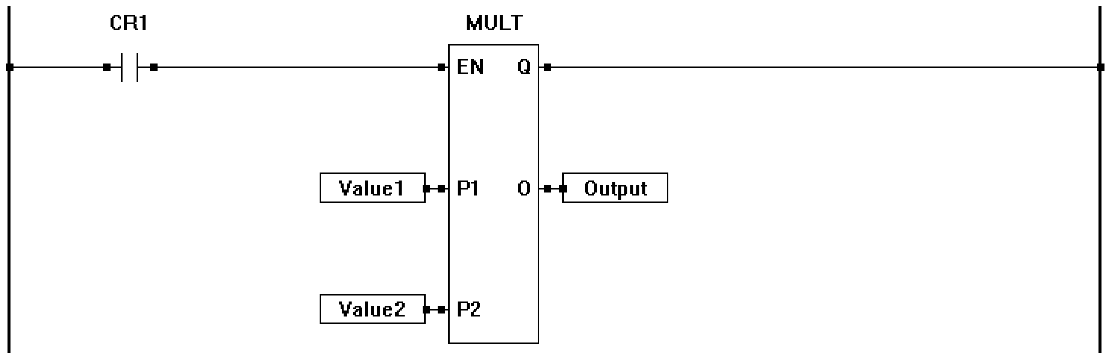
The MULT function multiplies all of the Px inputs together. The number of inputs is specified when the object is placed. The output (O) provides the result of the multiplication. The enable (EN) must be true for the MULT function to be enabled.

Input / Output Connections:

The MULT function block placement requires connections of at least 3 input pins (EN, P1, P2) and two output pins (Q, O). The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

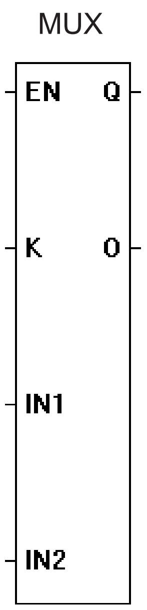
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P*x*	Input	X	X				Number of inputs is dynamic
O	Output	X	X				
Q	Output			X			

Example Circuit:



Related Functions: ADD, SUB, DIV

MUX



Description:

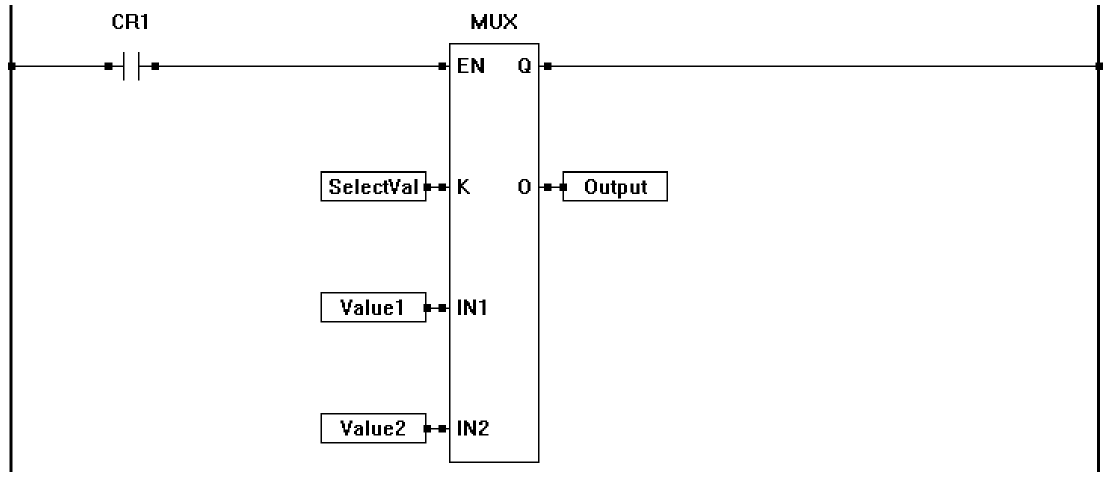
The MUX function multiplexes the INx inputs into one output (O). The number of inputs is specified when the object is placed. The output (O) provides the value of the selected input. The value on input K (starts at zero for IN1) determines the number of the input that will be present on the output. The enable (EN) must be true for the MUX function to be enabled.

Input / Output Connections:

The MUX function block placement requires connections of at least four input pins (EN, K, IN1, IN2) and two output pints (Q, O).

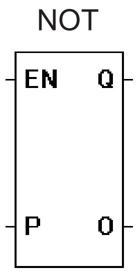
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
K	Input	X					
IN*x*	Input	X	X				
Q	Output			X			
O	Output	X	X				= Value of INx selected by K

Example Circuit:



Related Functions: SEL

NOT



Description:

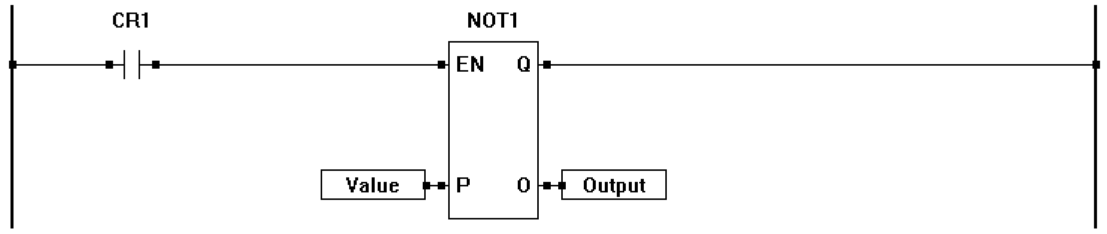
The NOT function provides a one's complement (bit to bit negation) of the P input. The output (O) provides the one's complement. The enable (EN) must be true for the NOT function to be enabled.

Input / Output Connections:

The NOT function block placement requires connections of two input pins (EN, P) and two output pins (Q, O).

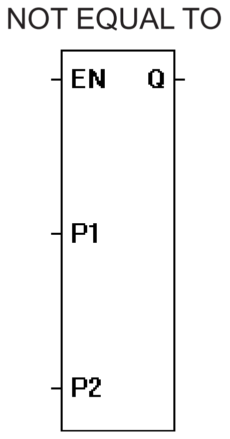
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P	Input	X					
O	Output	X					One's Complement of P
Q	Output			X			

Example Circuit:



Related Functions: OR, AND, XOR

NOT EQUAL TO (<>)



Description:

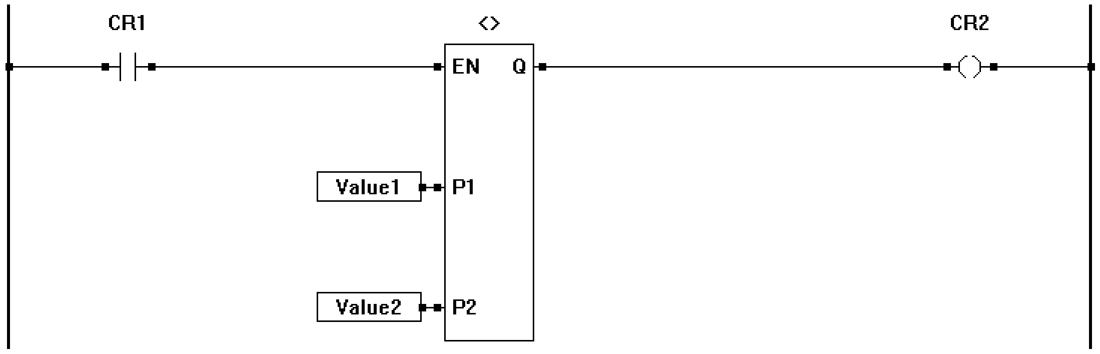
The NOT EQUAL TO provides an if greater than or less than comparison for the Px inputs. The number of inputs is specified when the object is placed. The output (Q) is true if P1 is not equal to P2 and P2 is not equal to P3 and so on. The enable (EN) must be true for the NOT EQUAL TO function to be enabled.

Input / Output Connections:

The NOT EQUAL TO function block placement requires connections of at least 3 input pins (EN, P1, P2) and one output pin (Q). The EN is always considered an input in the total number of inputs, therefore always add one to the number of P*x* inputs that need to be used.

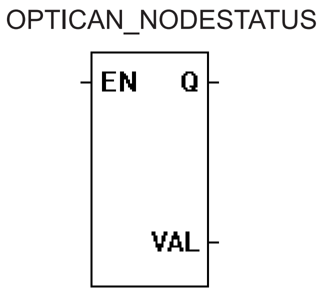
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P*x*	Input	X	X				Number of inputs is dynamic
Q	Output			X			

Example Circuit:



Related Functions: =, <, >, >=, <=

OPTICAN_NODESTATUS



Description:

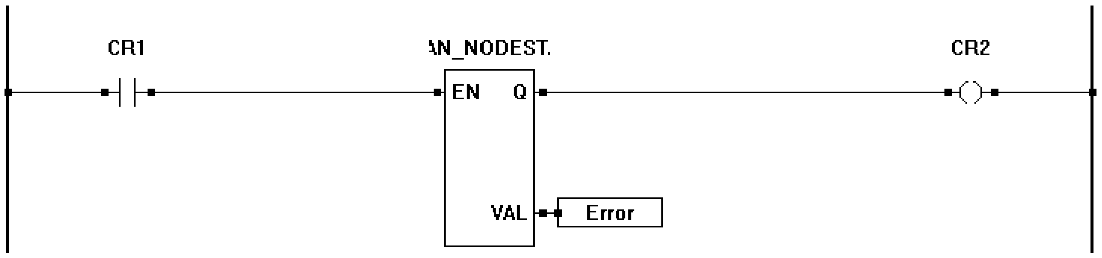
The OPTICAN_NODESTATUS function *listens* for OK of the status register (191) for the specified node over the OptiCAN network. When placing the function, the NODE ID is specified as well as the Timeout. The function block will *listen* for the node status register broadcast of the Node ID and update VAL and Q accordingly. The Timeout value is the duration that the function block will *listen* and not receive a status prior generating an Error on the VAL output pin and the Q output. The Q output is true when the VAL output is valid. See **Chapter 14 - OptiCAN Networking** for more information regarding using the function block and general OptiCAN networking.

Input / Output Connections:

The OPTICAN_NODESTATUS function block placement requires connections of one input pin (EN) and two output pins (Q, VAL).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
O	Output	X					See Error Codes
Q	Output			X			

Example Circuit:



Error Codes:

The Node Status register (191) is represented by a 32 bit number. The lower 16 bits represents the current **status code** while the upper 16 bits represents the **error code**.

There are three status codes supported on the OptiCAN network. The status codes are: 1 = Reset, 2 = Active, and 4 = Reset.

The Q output will be true if the VAL output is valid. If invalid (no response from node), then the Q output will be false and the VAL output will equal zero.

Error codes are divided into two groups. Device specific errors are numbered 0-32767 while common error codes are numbered 32768-65535.

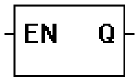
Common Error Codes are as follows:

65535 = CAN Controller Receive Error	65531 = CAN Controller Bus Off State
65534 = CAN Controller Receive Warning	65530 = CAN Controller Data Overrun
65533 = CAN Controller Transmit Error	65519 = OptiCAN Heartbeat Timeout
65532 = CAN Controller Transmit Warning	65518 = CAN Controller Error

Related Functions: OPTICAN_TXNETMSG

OPTICAN_TXNETMSG

OPTICAN_TXNETMSG



Description:

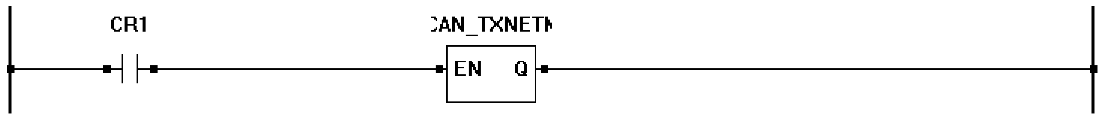
The OPTICAN_TXNETMSG function broadcasts the network control commands Start Network, Stop Network and Reset Network on the OptiCAN network. This function block globally broadcasts, therefore affecting all connected nodes. A Start Network command must be broadcast after power up to start the OptiCAN network nodes communications. When placing the function, a dialog box provides the selection of the type of command to send and an optional description box. See **Chapter 14 - OptiCAN Networking** for more information regarding using the function block and general OptiCAN networking.

Input / Output Connections:

The OPTICAN_TXNETMSG function block placement requires connections of one input pin (EN) and one output pin (Q).

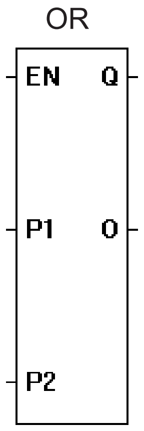
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
Q	Output			X			

Example Circuit:



Related Functions: OPTICAN_NODESTATUS

OR



Description:

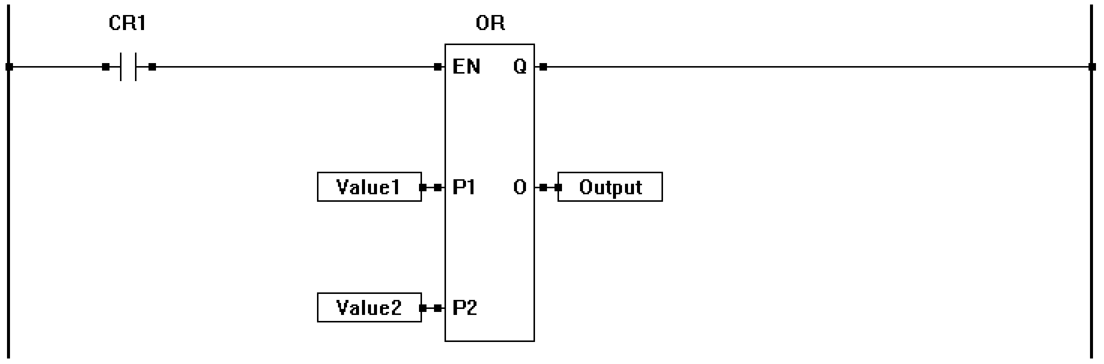
The OR function provides a bitwise OR function of the P1 and P2 inputs. The enable (EN) must be true for the OR function to be enabled. The Q output is true when the OR function is enabled.

Input / Output Connections:

The OR function block placement requires connections of 3 input pins (EN, P1, P2) and two output pins (Q, O).

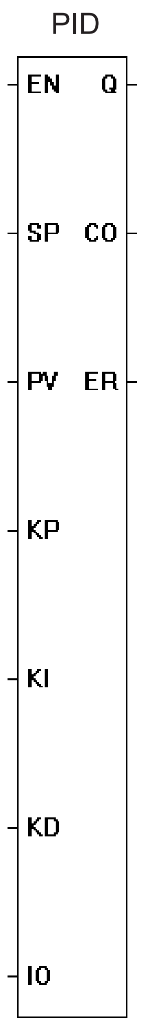
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X					
P2	Input	X					
O	Output	X					
Q	Output			X			

Example Circuit:



Related Functions: XOR, AND, NOT

PID



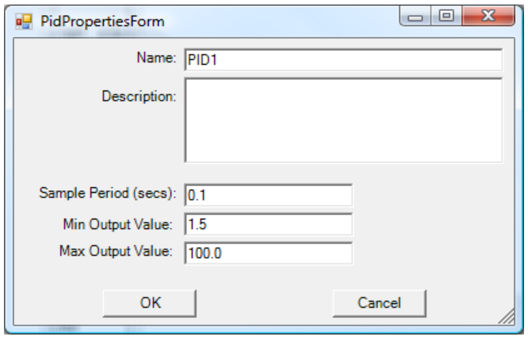
Description:

The PID function provides an easy to use PID control algorithm. Specific PID information is required when the function is placed as well as the PID inputs. The Q is true when the function is enabled. The CO (Control Output) is the output calculated by the PID. The ER is the error calculation of the PID (SP-PV). The PID function is defined by the difference Equation:

$$u(n) = u(n-1) + Kp[e(n) - e(n-1)] + Ki\,[T * e(n)] + (Kd / T)[e(n) - 2 * e(n-1) + e(n-2)]$$

Where:

$u(n)$ = PID Output	Kp = Proportional Gain	Ki = Integral Gain
Kd = Derivative Gain	$e(n)$ = Error (Setpoint - Process Variable)	T = Sample Period



Name: PID1
Description:
Sample Period (secs): 0.1
Min Output Value: 1.5
Max Output Value: 100.0

Name:	Name of the PID function.
Description:	Enter a description.
Sample Period (Secs):	The sample period in seconds (Min = .01S, Max = 86,400S), sample period resolution = 50µS.
Minimum Output Value:	Minimum PID Output value allowed.
Maximum Output Value:	Maximum PID Output value allowed.

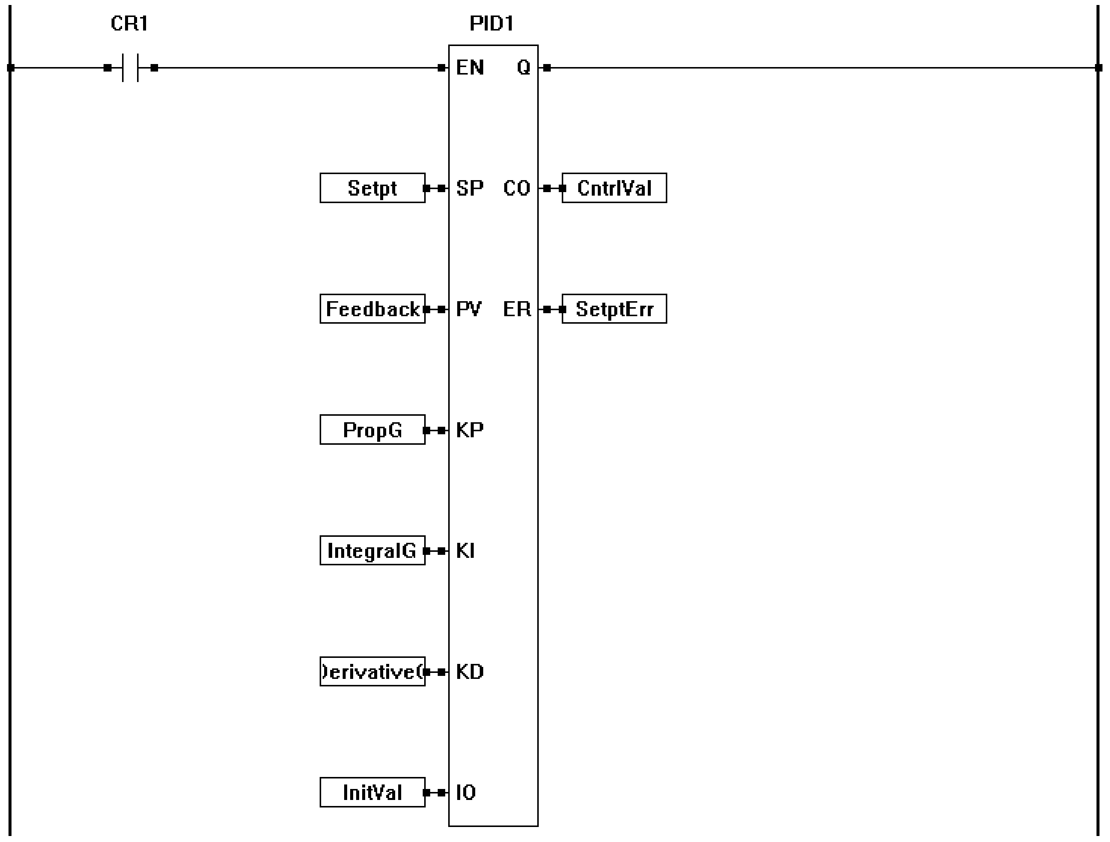
If SP, PV or process error is determined not to be infinite values, the error flag is set and the CO is set to the IO value. When these values are valid (infinite) again, the PID function will return to normal.

Input / Output Connections:

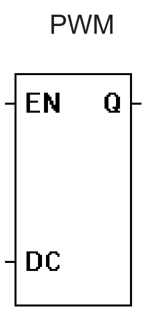
The PID function block placement requires connections of 7 input pins (EN, SP, PV, KP, KI, KD, IO) and 3 output pins (Q, CO, ER).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
SP	Input		X				Control Set Point
PV	Input		X				Process Feedback Variable
KP	Input		X				Proportional Gain
KI	Input		X				Integral Gain
KD	Input		X				Derivative Gain
IO	Input		X				Initial Value, PID is init to this value
CO	Output		X				Control Output - Calculated Signal
ER	Output		X				Error = Amount of error from set point
Q	Output			X			

Example Circuit:



PWM



Description:

The PWM function controls the function of a hardware PWM output channel (this channel is specified when the function is placed). When the EN is true, the hardware PWM channel outputs a square wave with the specified duty cycle (DC) at the frequency pre-programmed (this frequency is determined by the PWM channel and is configured when the PWM channel is installed in the target settings menu unless the PWM_FREQ function overrides this frequency with it's own). The Q output is true when the function is enabled.

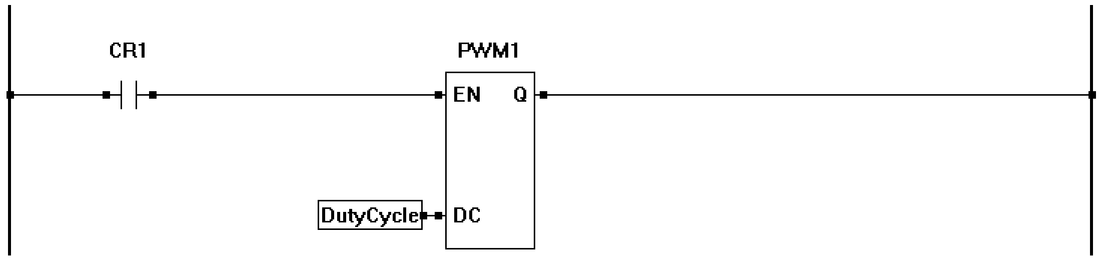
When the PWM function is placed, you must specify the actual hardware PWM channel that the function will control and the Polarity (Starting Low will cause the PWM channel to start with a TTL low, Starting High will cause the PWM channel to start with a TTL high). Refer to **Chapter 8 - Pulse Width Modulation** for details on PWM functionality.

Input / Output Connections:

The PWM function block placement requires connections of two input pins (EN, DC) and one output pin (Q).

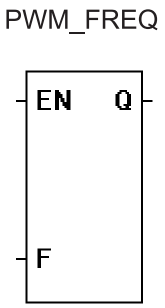
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
DC	Input	X	X				
Q	Output			X			

Example Circuit:



Related Functions: PWM_FREQ

PWM_FREQ



Description:

The PWM_FREQ function controls the frequency of a hardware PWM output channel (this channel is specified when the function is placed). When the EN sees a low to high transition, the hardware PWM channel's frequency is changed from it's current value (either from when the PWM channel was installed using the Target..Settings menu or a PWM_FREQ function).

The PWM_FREQ only changes the hardware PWM channel's frequency with a low to high transition on EN. This frequency will be maintained regardless of the EN state. The only time this frequency will change again is when the actual frequency input variable (input F) changes and the EN detects another low to high transition. Q is true during the ladder diagram scan when the frequency is newly applied. All other times, the Q output is low.

When the PWM function is placed, you must specify the actual PWM channel group (CLK A or CLK B) that the function will change the frequency to.

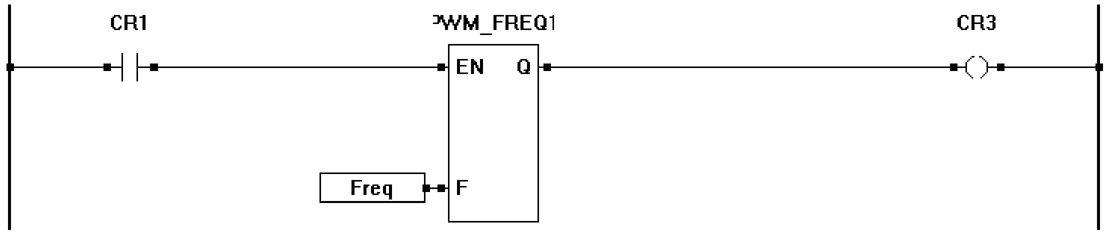
If an invalid frequency is applied to input to F, then the Q Output will remain low as well as the actual PWM output.

Input / Output Connections:

The PWM function block placement requires connections of two input pins (EN, F) and one output pin (Q).

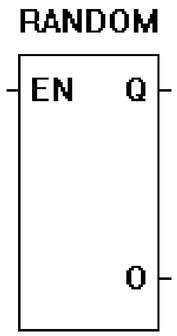
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Rising Edge	
F	Input	X	X				Input Frequency
Q	Output			X			

Example Circuit:



Related Functions: PWM

RANDOM



Description:

The RANDOM functions provides a random number based on the SEED (function) value. The enable (EN) must be true for the RANDOM function to be enabled. The Q output is true when the RANDOM function is enabled. The output (O) is the random number.

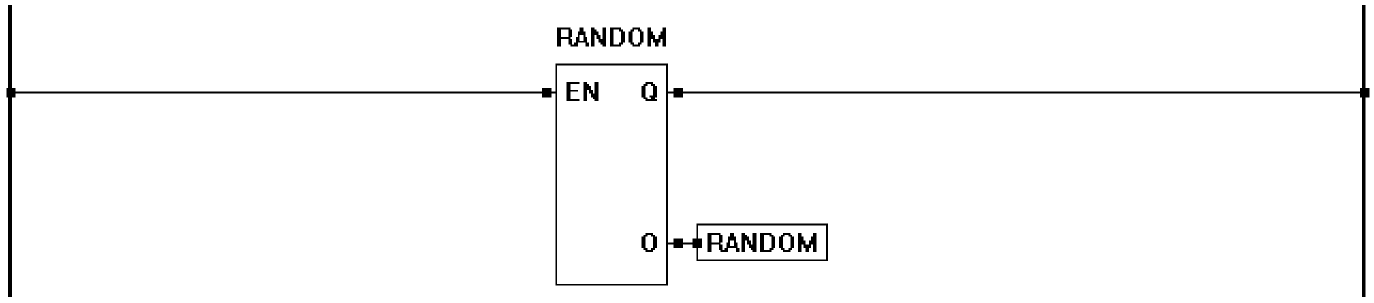
The RANDOM function is designed to be used with the SEED function. Without the SEED, the output will not be random.

Input / Output Connections:

The RANDOM function block placement requires connections of one input pin (EN) and two output pins (Q, O).

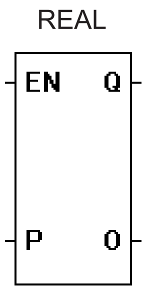
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
O	Output	X					Random Integer Number
Q	Output			X			

Example Circuit:



Related Functions: SEED

REAL



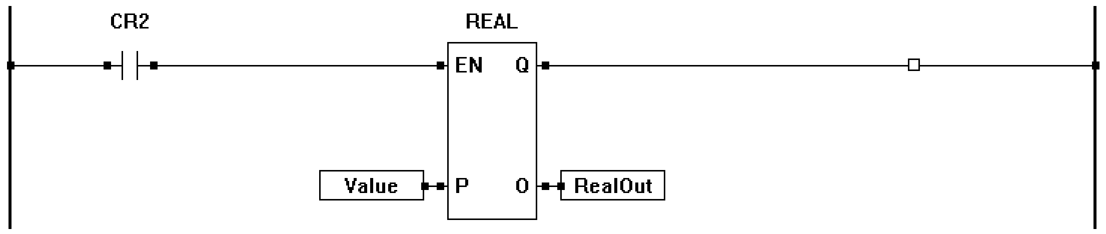
Description:
The REAL function converts the input (P) into an real output (O). The enable (EN) must be true for the REAL function to be enabled. The Q output is true when the REAL function is enabled.

In addition to converting a Boolean, Timer or Integer to an real, the REAL function block can be used to copy one real to another.

Input / Output Connections:
The REAL function block placement requires connections of two input pins (EN, P) and two output pins (Q, O).

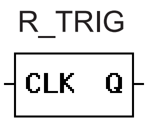
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P	Input	X	X	X	X		
O			X				
Q	Output			X			

Example Circuit:



Related Functions: TIMER, BOOLEAN, INTEGER

R_TRIG



Description:

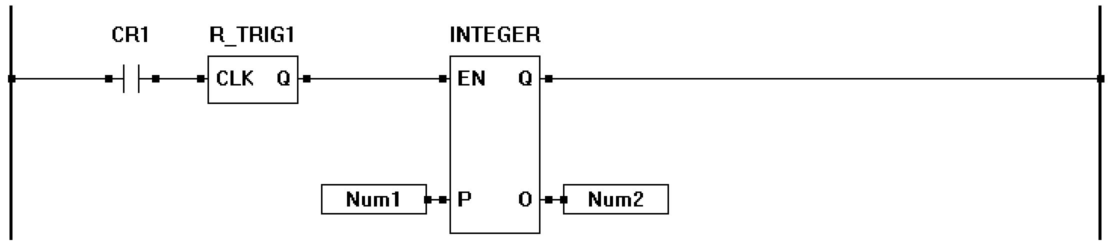
The R_TRIG is a function that may be used to trigger another function on the rising edge of a transition. When the CLK detects a false to true transition, the output (Q) is energized for one scan of the program only.

Input / Output Connections:

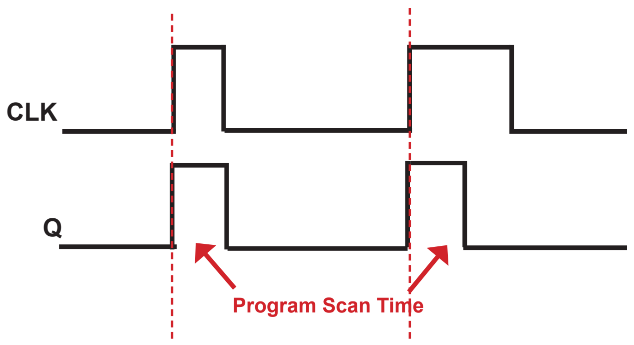
The R_TRIG function block placement requires connections of one input pin (CLK) and one output pin (Q).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
CLK	Input			X		Falling Edge	
Q	Output			X			True for only one scan

Example Circuit:

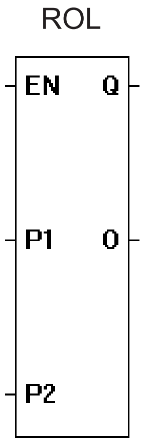


Timing Diagram:



Related Functions: F_TRIG

ROL



Description:

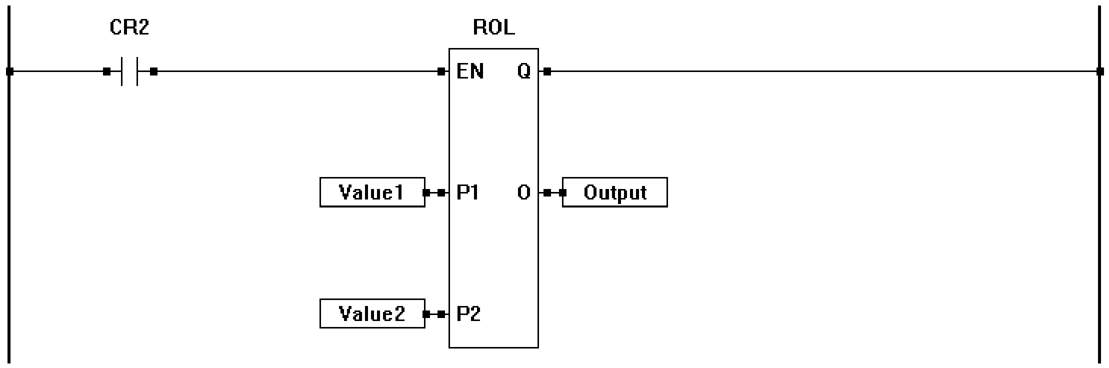
The ROL function provides a left-bit rotation of the P1 input. P2 specifies the number of one-bit rotations. The P1 number is a integer representation of a binary number. The P2 number is an integer representation of the number of binary rotations (shifts) to occur to P1. The actual bit only rotates when the maximum number is reached (example: 32 bit rotation to the input number 1).The enable (EN) must be true for the ROL function to be enabled. The Q output is true when the ROL function is enabled. The O Output is the rotated number (represented in integer form).

Input / Output Connections:

The ROL function block placement requires connections of 3 input pins (EN, P1, P2) and two output pins (Q, O).

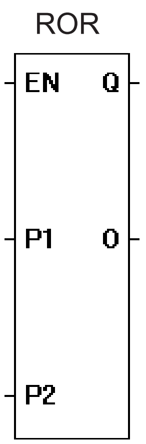
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X					
P2	Input	X					
O	Output	X					
Q	Output			X			

Example Circuit:



Related Functions: ROR

ROR



Description:

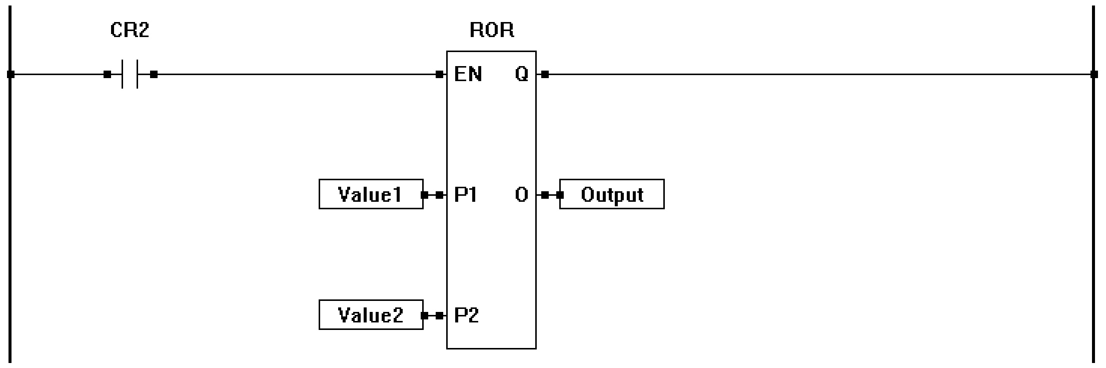
The ROR function provides a right-bit rotation of the P1 input. P2 specifies the number of one-bit rotations. The P1 number is a integer representation of a binary number. The P2 number is an integer representation of the number of binary rotations (shifts) to occur to P1. The actual bit only rotates when the minimum number is reached (example: 32 bit rotation to the input number 32). The enable (EN) must be true for the ROR function to be enabled. The Q output is true when the ROR function is enabled. The O Output is the rotated number (represented in integer form).

Input / Output Connections:

The ROR function block placement requires connections of 3 input pins (EN, P1, P2) and two output pins (Q, O).

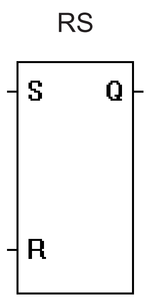
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X					
P2	Input	X					
O	Output	X					
Q	Output			X			

Example Circuit:



Related Functions: ROL

RS



Description:

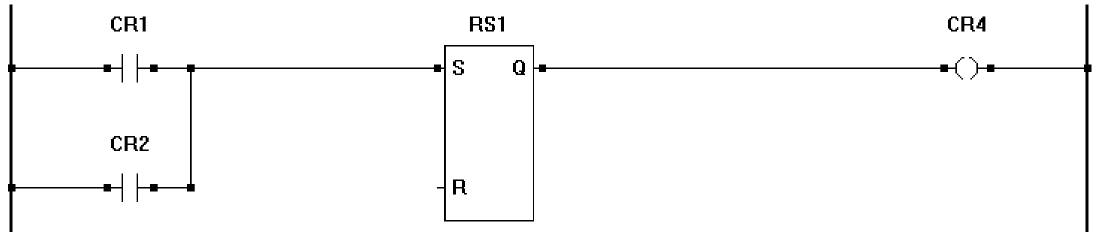
The RS function acts as a reset dominant bistable. If the set input (S) is true, the output (Q) is true. A true on the reset (R) input sets the output (Q) to false (regardless of the set (S) input state).

Input / Output Connections:

The RS function block placement requires connections of two input pins (S,R) and one output pin (Q).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
R	Input			X			
S	Input			X			
Q	Output			X			

Example Circuit:

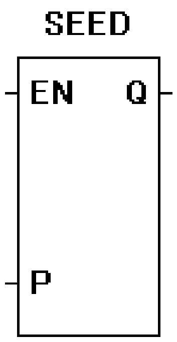


Truth Table:

SET	RESET	Q	Q RESULT
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

Related Functions: SR

SEED



Description:

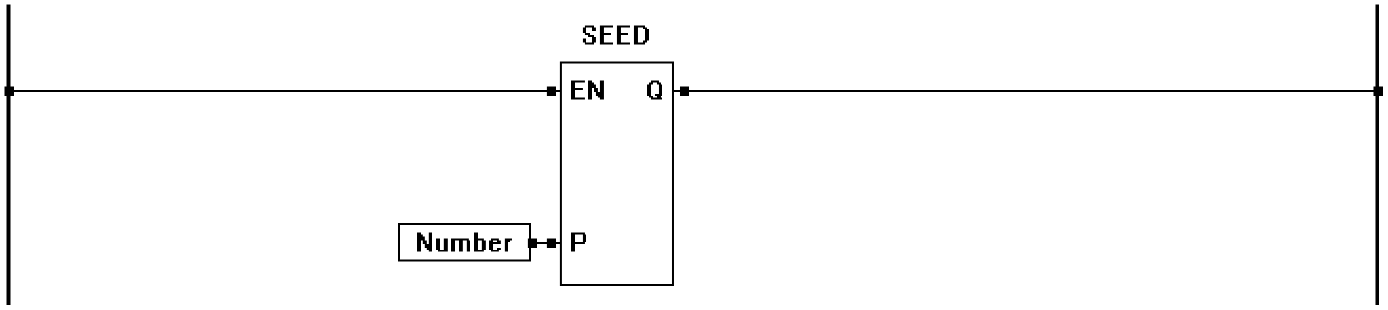
The SEED function provides the number which the RANDOM function uses as the basis for generating a random number. The enable (EN) must be true for the SEED function to be enabled. The Q output is true when the SEED function is enabled.

Input / Output Connections:

The SEED function block placement requires connections of two input pins (EN, P) and one output pins (Q).

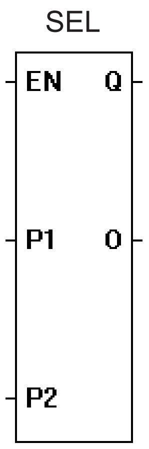
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P	Input	X					
Q	Output			X			

Example Circuit:



Related Functions: RANDOM

SEL



Description:

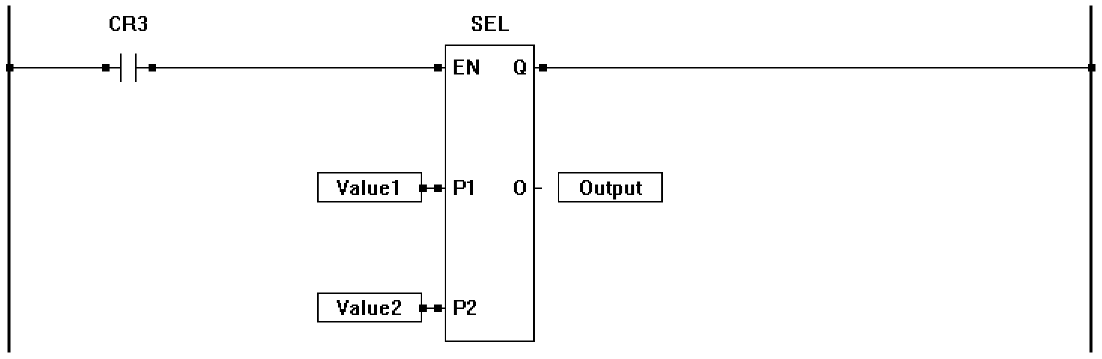
The SEL function provides selection of the P1 or P2 inputs. If enable (EN) is false, the output (O) will be equal to the input P1. If the enable (EN) is true, the output (O) will be equal to the input P2. The Q output is true when the SEL function is enabled.

Input / Output Connections:

The SEL function block placement requires connections of 3 input pins (EN, P1, P2) and two output pins (Q, O).

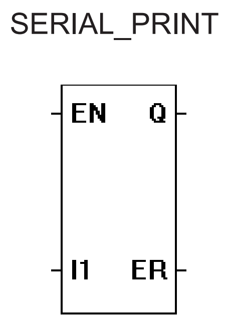
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X	X				
P2	Input	X	X				
O	Output	X	X				
Q	Output			X			

Example Circuit:



Related Functions: MUX

SERIAL_PRINT



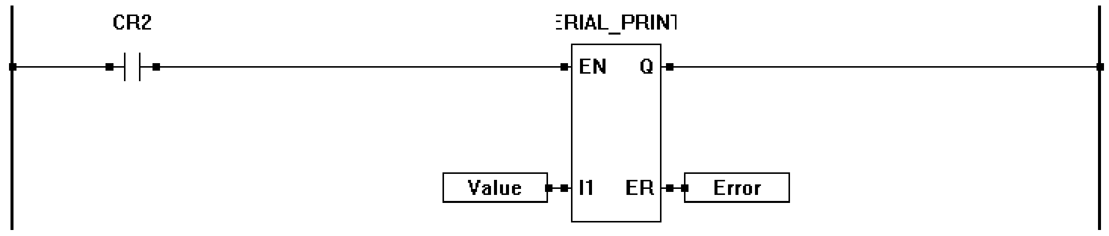
Description:
The SERIAL_PRINT function is the transmit block for sending serial information using a multi-purpose serial port.

When then EN input senses a rising edge, the block begins the serial transmission of its text that was provided when the SERIAL_PRINT function was placed. The Q output is set true when the transmission is completed. The ER output is set true if there is still data in the buffer when the function block is enabled to transmit again. See **Chapter 11 - Serial Printing**.

Input / Output Connections:
The SERIAL_PRINT function block placement requires connections of at least one input pin (EN) and two output pins (Q, ER). Additional inputs are based on variables in serial text.

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Rising Edge	
ERR	Output	X					Set to non-zero if error
I*x*	Input	X	X	X			Dynamic Inputs
Q	Output			X			True when transmit is completed

Example Circuit:



Text / Message Formatting:
The SERIAL_PRINT function text formatted per ANSI C “printf”. The function block examples shown are for VT100 terminals. Variables as well as text may be printed. These variables must be formatted correctly. As variables are added to the *text,* the function block will automatically add the appropriate input for the variables.

Text
Text is entered exactly as the message is intended. Variables, special formats and escape codes are also added to this field. See the Variables, Other Special Variables and Formats and the Escape Sequence sections for details regarding adding special codes for specific needs.

Variables
Variables are placed in the text using flags and print specification fields. The following is the configuration for adding variables to the text.

%*flag* width .precision Example Text: OIL PSI %-3d

% - identifies the beginning of a variable or other type of text entry
flag - This flag is optional. Use the following flags to change the way data is transmitted.

Flag	Description
-	Left align the variable within the specified *width*. Default is align right.
0	If width is prefixed with 0, leading zeros are added until the minimum width is reached. If 0 and - are used together, the 0 is ignored. If 0 is specified in an integer format, the 0 is ignored.

width -	This flag is optional. Width is the number of characters that will be printed (total).
.precision -	This flag is optional. The precision is the number of digits after the decimal point when using REAL variables.

Variable Formats
Variables are formatted based on the variable type. The following are supported variable types and their format.

%d	Signed Integer	%X	Upper Case Hexadecimal
%u	Unsigned Integer	%f	Real or Float Variable
%x	Lower Case Hexadecimal	%b	binary
%o	Octal		

Other Special Characters & Formats

To Print	Use	To Print	Use
%	%%	OFF / ON	%O
Boolean 0 or 1	%d	FALSE / TRUE	%T

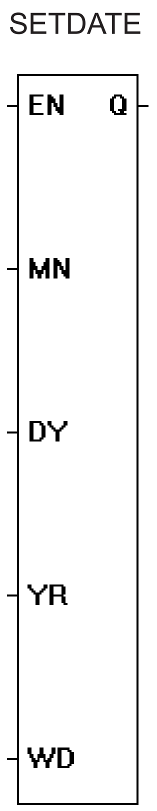
Examples:	Format	Result	Format	Result
	OIL: %d	OIL: 25	OIL: %04d	OIL: 0025
	LS1: %T	LS1: TRUE	LS1: %O	LS1: OFF
	TEMP: %6.2f	TEMP: 234.12	TEMP: %3.f	TEMP: 234

Escape Sequences located on next page.

Special Printing Codes (Escape Sequences)

Escape Sequence	Represents
\a	Bell (Alert)
\b	Backspace
\f	Form Feed
\n	New Line
\r	Carriage Return
\t	Horizontal Tab
\’	Single Quotation Mark
\”	Double Quotation Mark
\?	Literal Question Mark
\\	BackSlash
\ooo	ASCII character in Octal notation
\xhh	ASCII character in Hexadecimal notation, stops on last non-hex character.
\uhhhh	Prints hexidecimal, always uses 4 characters

SETDATE



Description:

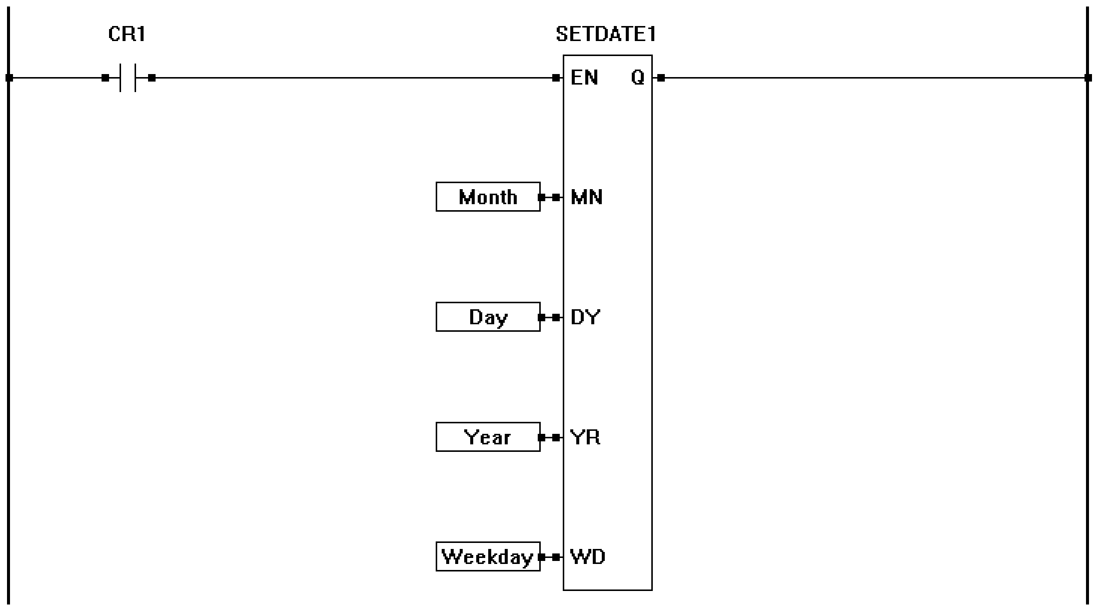
The SETDATE function sets the current date on the hardware real time clock. The date is set by using variables to apply values to each of the inputs. The enable (EN) must be true for the SETDATE function to be enabled. The Q output is true when the function is enabled. The MN input sets the month (1-12), the DY input sets the day of the month (1-31) , the YR input sets the current year (last two digits) and the WD sets the day of the week (1-7, 1=Sunday). The MN, DY, YR and WD inputs must be connected to Integer variables.

Input / Output Connections:

The SETDATE function block placement requires connections of 5 input pins (EN, MN, DY, YR, WD) and one output pin (Q).

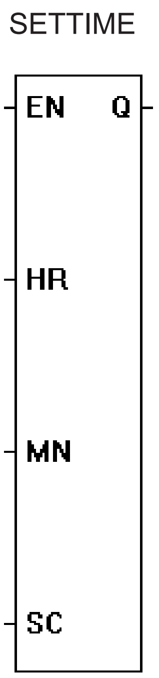
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State
EN	Input			X		Active True
Q	Output			X		
MN	Input	X				
DY	Input	X				
YR	Input	X				
WD	Input	X				

Example Circuit:



Related Functions: SETTIME, GETTIME, GETDATE

SETTIME



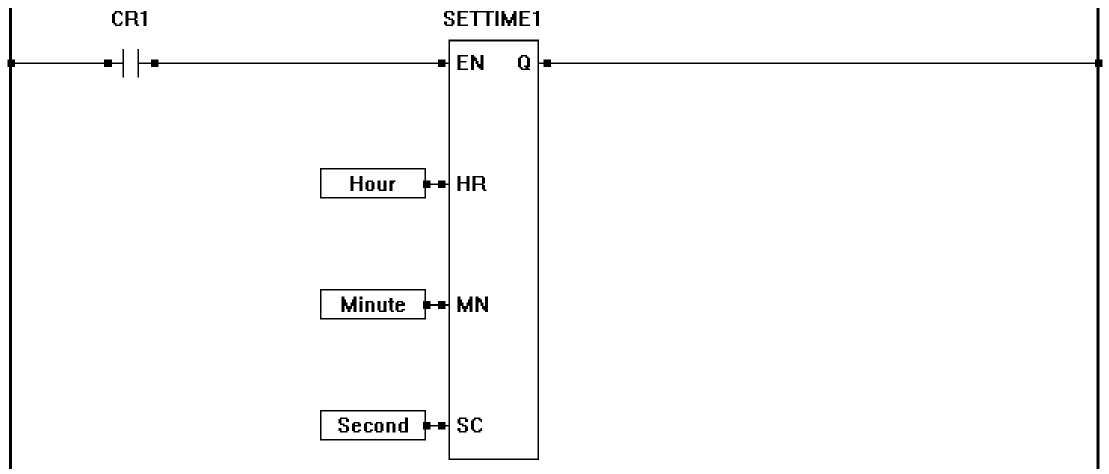
Description:
The SETTIME function sets the current time on the hardware real time clock. The time is set by using variables to apply values to each of the inputs. The enable (EN) must be true for the SETTIME function to be enabled.

The Q output is true when the function is enabled. The HR input sets the hour of the day (0-23) , the MN input sets the minutes (0-59) and the SC sets the seconds (0-59). The HR, MN and SEC inputs must be connected to Integer variables.

Input / Output Connections:
The SETTIME function block placement requires connections of one input pin (EN) and four output pins (Q, HR, MN, SEC).

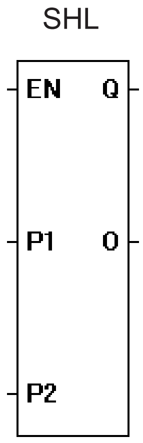
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State
EN	Input			X		Active True
Q	Output			X		
HR	Input	X				
MN	Input	X				
SC	Input	X				

Example Circuit:



Related Functions: SETDATE, GETTIME, GETDATE

SHL



Description:

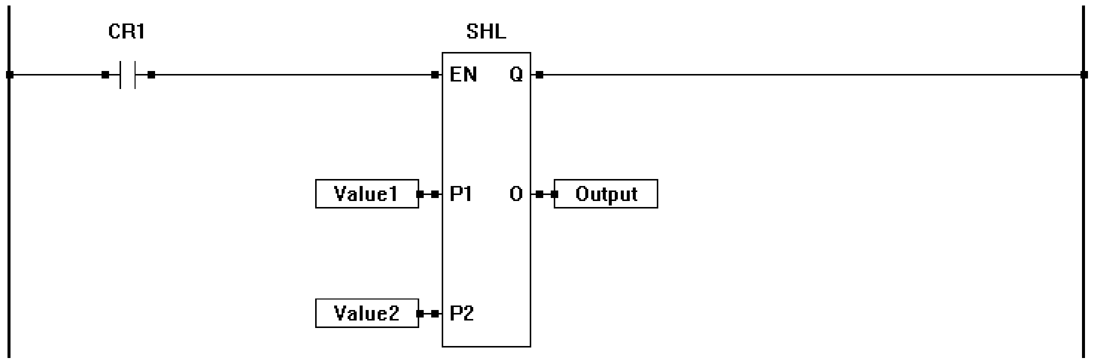
The SHL function provides a left bit shift of the P1 input. The P2 input specifies the number of one-bit left shifts. If the enable (EN) is false, the function is disabled. If the enable (EN) is true, the output (O) will be equal result of the left shifted input in integer form (1..2..4..8..16..32). A shift left when the output is 32 will cause the output to be zero (bit is shifted off). Zeros are always shifted on to the right side when a left shift occurs.

Input / Output Connections:

The SHL function block placement requires connections of 3 input pins (EN, P1, P2) and two output pins (Q, O).

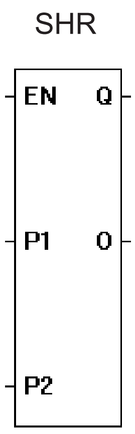
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X					
P2	Input	X					
O	Output	X					
Q	Output			X			

Example Circuit:



Related Functions: SHR

SHR



Description:

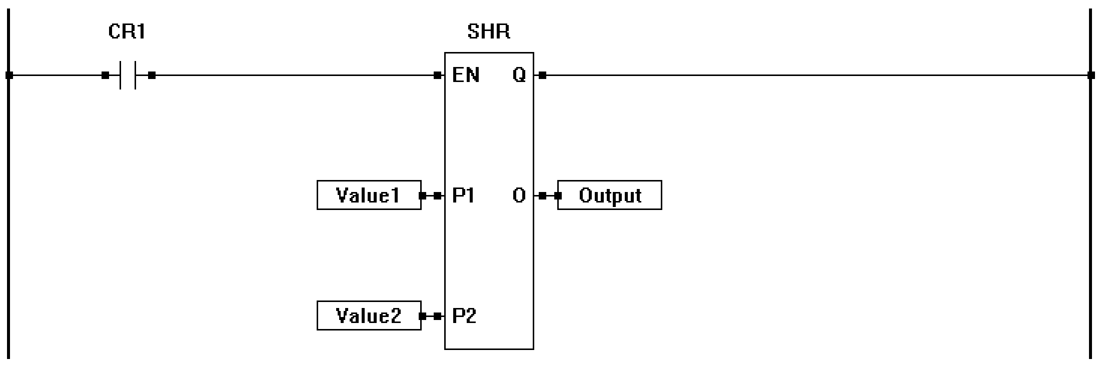
The SHR function provides a right bit shift of the P1 input. The P2 input specifies the number of one-bit right shifts. If the enable (EN) is false, the function is disabled. If the enable (EN) is true, the output (O) will be equal result of the right shifted input in integer form (32..16..8..4..2..1). A shift right when the output is 1 will cause the output to be zero (bit is shifted off). Zeros are always shifted on to the left side when a right shift occurs.

Input / Output Connections:

The SHR function block placement requires connections of 3 input pins (EN, P1, P2) and two output pins (Q, O).

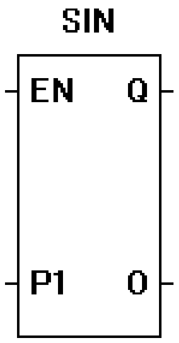
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X					
P2	Input	X					
O	Output	X					
Q	Output			X			

Example Circuit:



Related Functions: SHL

SIN

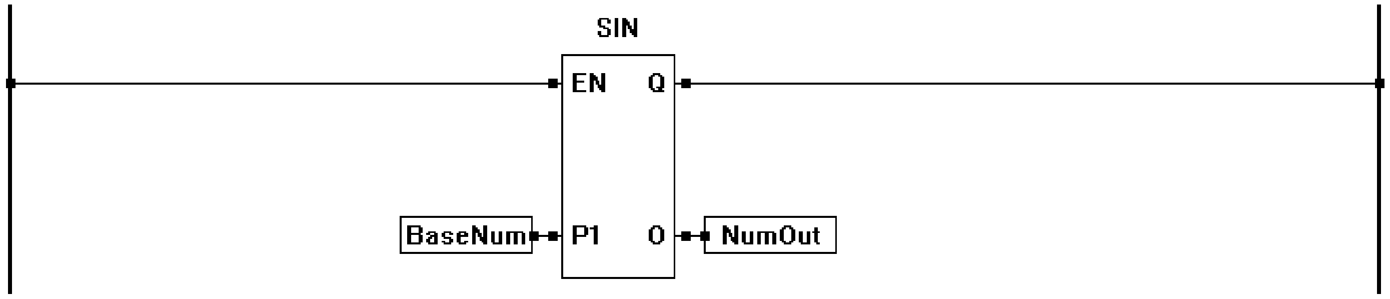


Description:
The SIN function provides the sine (O) from the input value (P1). The enable (EN) must be true for the SIN function to be enabled. The Q output is true when the SIN function is enabled.

Input / Output Connections:
The SIN function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

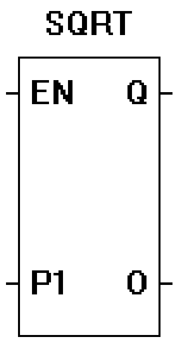
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Sine of P1 Base Number

Example Circuit:



Related Functions: ASIN, ATAN, COS, TAN, ACOS

SQRT

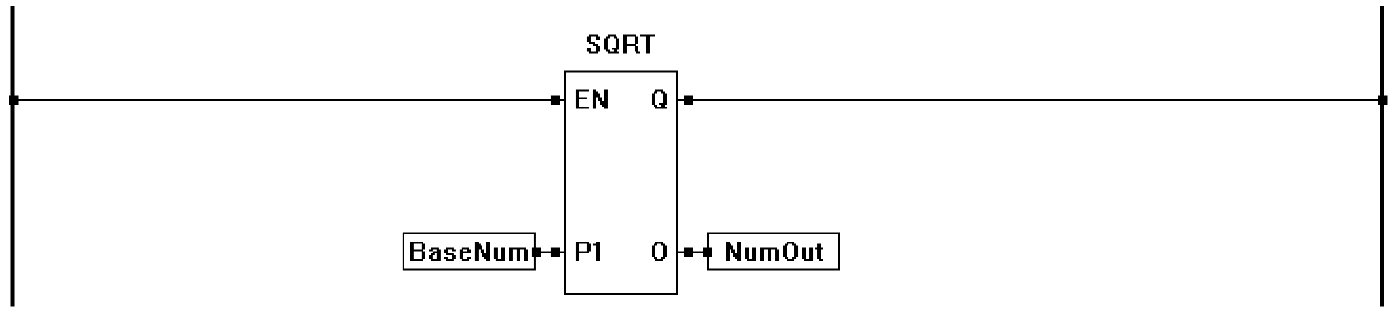


Description:
The SQRT function provides the square root (O) from the input value (P1). The enable (EN) must be true for the SQRT function to be enabled. The Q output is true when the SQRT function is enabled.

Input / Output Connections:
The SQRT function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

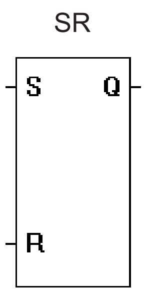
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Square Root of P1 Base Number

Example Circuit:



Related Functions: EXP, EXPT, LOG, LN

SR



Description:

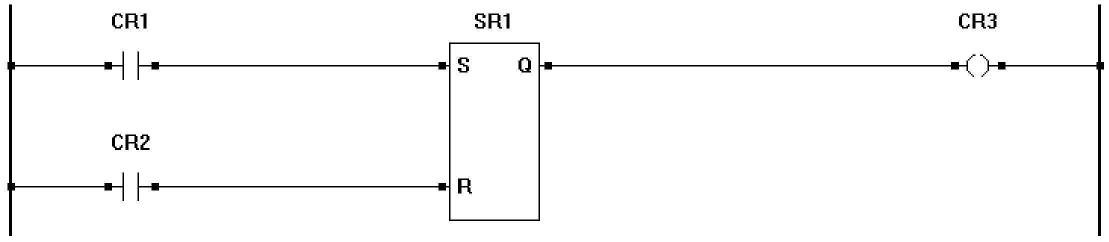
The SR function acts as a set dominant bistable. If the set input (S) is true, the output (Q) is true. A true on the reset (R) input sets the output (Q) to false only if the set (S) input is also false.

Input / Output Connections:

The SR function block placement requires connections of two input pins (S,R) and one output pin (Q).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
R	Input			X			
S	Input			X			
Q	Output			X			

Example Circuit:

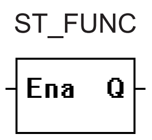


Truth Table:

SET	RESET	Q	Q RESULT
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

Related Functions: RS

ST_FUNC



Description:

The ST_FUNC function is a function block for using structured-text functions created in EZ LADDER Toolkit. The ST_FUNC has only local variables and will not allow variables (items) to pass from one ladder scan to another (ie: keeping track of a count). As this uses less memory, it is ideal for using when scan-passing is not required as it uses less overhead (memory). The Enable is used to enable the function and the Q output is active when the function enable is true.

For understanding on Structured Text and how the ST_FUNC operates with structured text functions, refer to **Chapter 26 - Structured Text**.

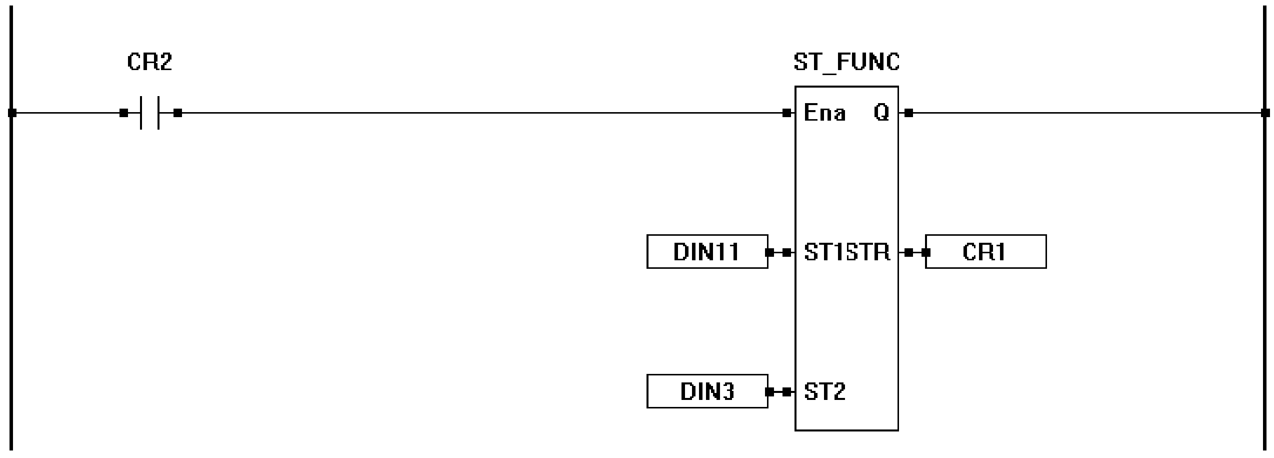
Input / Output Connections:

Before an ST_FUNC function may be used in a ladder diagram (called from a ladder diagram program, certain criteria must be met. Refer to Chapter 26-Structured Text for this criteria.

Input and Output connections are based on the structured text functions you create in EZ LADDER (ST Function Editor). The Enable and Q outputs are by default created.

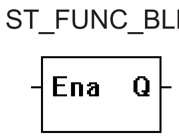
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
Enable	Input			X		Active True	
Q	Output			X			True when EN is true
XX	XX	X	X	X	X		Input/Output Name & Type based solely on User Structured Text Function.

Example Circuit:



Related Functions: ST_FUNC_BLK

ST_FUNC_BLK



Description:

The ST_FUNC_BLK function is a function block for using structured-text functions created in EZ LADDER Toolkit. The ST_FUNC may use local or global variables and will allow variables (items) to pass from one ladder scan to another (ie: keeping track of a count). This function uses more memory than the ST_FUNC function. The Enable is used to enable the function and the Q output is active when the function enable is true.

For understanding on Structured Text and how the ST_FUNC_BLK operates with structured text functions, refer to **Chapter 26 - Structured Text**.

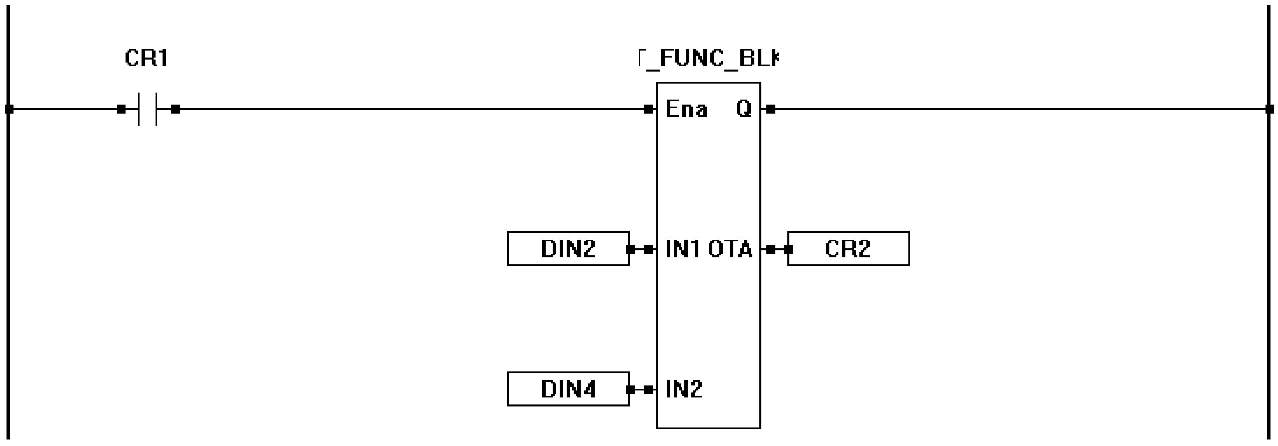
Input / Output Connections:

Before an ST_FUNC function may be used in a ladder diagram (called from a ladder diagram program, certain criteria must be met. Refer to Chapter 26-Structured Text for this criteria.

Input and Output connections are based on the structured text functions you create in EZ LADDER (ST Function Editor). The Enable and Q outputs are by default created.

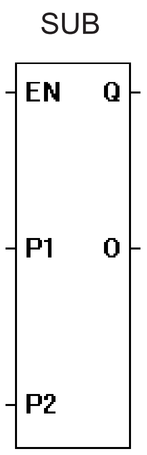
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
Enable	Input			X		Active True	
Q	Output			X			True when EN is true
XX	XX	X	X	X	X		Input/Output Name & Type based solely on User Structured Text Function.

Example Circuit:



Related Functions: ST_FUNC

SUB



Description:

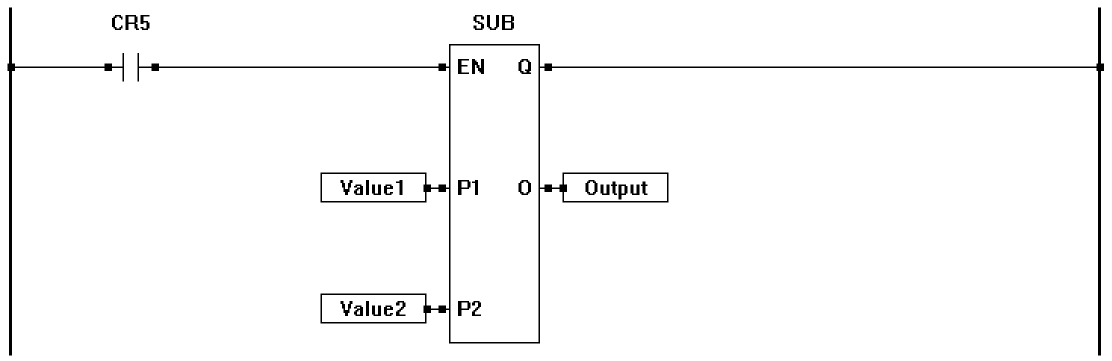
The SUB functions subtracts the P2 input from the P1 input. The output (O) is the result of the subtraction. The enable (EN) must be true for the SUB function to be enabled. The Q output is true when the SUB function is enabled.

Input / Output Connections:

The SUB function block placement requires connections of 3 input pins (EN, P1, P2) and two output pins (Q, O).

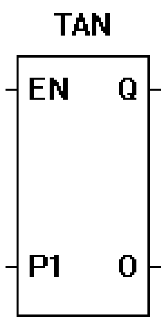
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X	X				
P2	Input	X	X				
O	Output	X	X				
Q	Output			X			

Example Circuit:



Related Functions: ADD, MULT, DIV, ABS

TAN



Description:

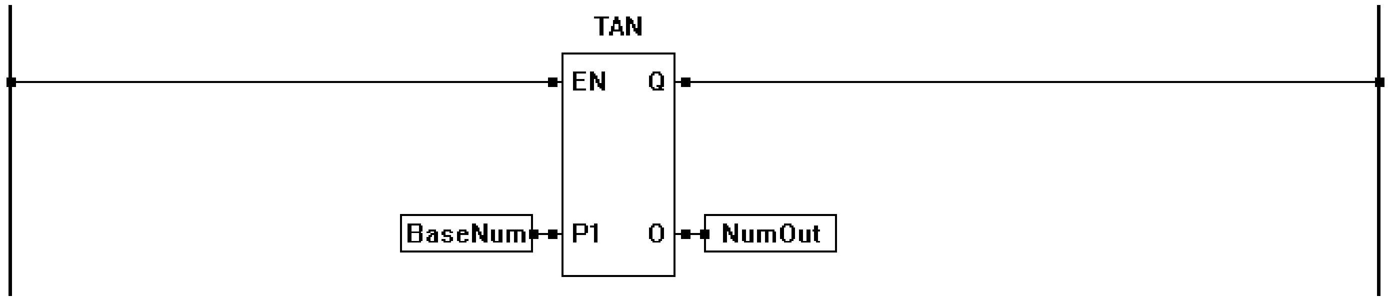
The TAN function provides the Tangent (O) from the input value (P1). The enable (EN) must be true for the TAN function to be enabled. The Q output is true when the TAN function is enabled.

Input / Output Connections:

The TAN function block placement requires connections of two input pins (EN, P1) and two output pins (Q, O).

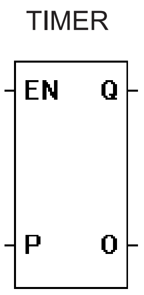
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input		X				Base Number
Q	Output			X			
O	Output		X				Tangent of P1 Base Number

Example Circuit:



Related Functions: ASIN, ATAN, COS, SIN, ACOS

TIMER



Description:

The TIMER function converts the input (P) into an Timer output (O). The enable (EN) must be true for the TIMER function to be enabled. The Q output is true when the TIMER function is enabled. The O output is a representation of the P input value in milliseconds (5=5ms, 1000=1 Second)

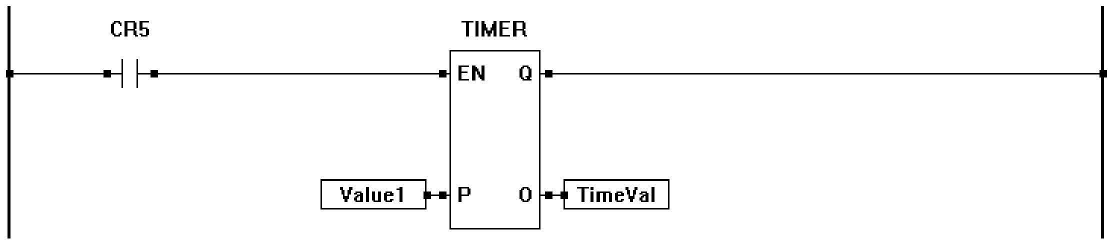
In addition to converting an Integer or Real to a Timer, the Timer function block can be used to copy one timer to another.

Input / Output Connections:

The TIMER function block placement requires connections of two input pins (EN, P) and two output pins (Q, O).

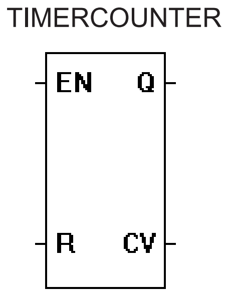
I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P	Input	X	X		X		
O					X		
Q	Output			X			

Example Circuit:



Related Functions: INTEGER, REAL, BOOLEAN

TIMERCOUNTER



Description:

The TIMERCOUNTER function block is used to read counter or timer values of the real world inputs connected to the Timer / Counter Capture inputs (pins). The enable (EN) must be true for the TIMERCOUNTER function to be enabled. The Q output is true when the TIMERCOUNTER function is enabled. The CV output is the actual count or time value (based on how the input is configured). The reset (R) input is used to reset the counter or timer.

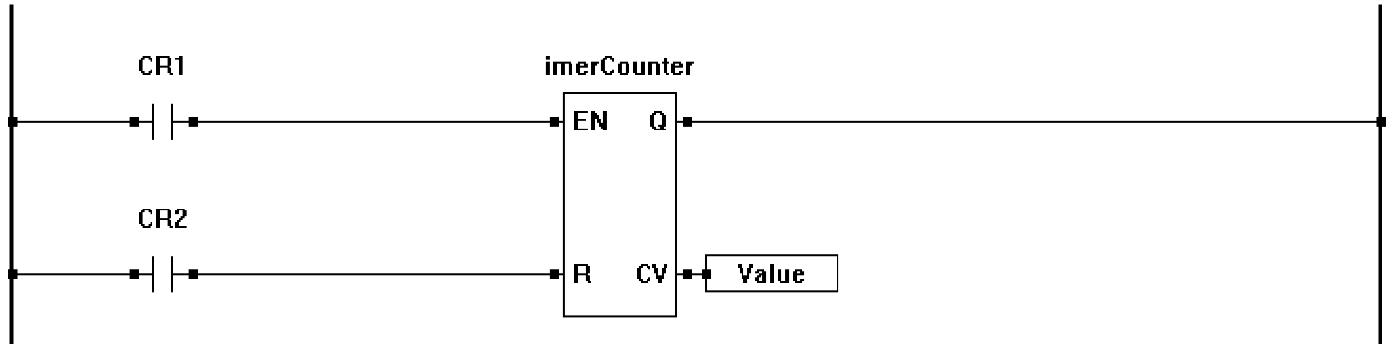
Counter / Timer Capture inputs may be configured as Timers, Free Running Timers or Counters. The capture input(s) must be configured in the EZ LADDER Toolkits Target Settings prior to placing in the ladder diagram.

Input / Output Connections:

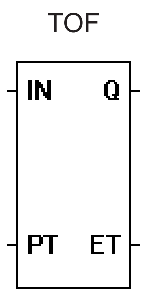
The TIMER function block placement requires connections of two input pins (EN, R) and two output pins (Q, CV).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
R	Input			X		Active True	Resets Counte/Timer
CV	Output	X					Actual Count / Timer Value
Q	Output			X			

Example Circuit:



TOF



Description:

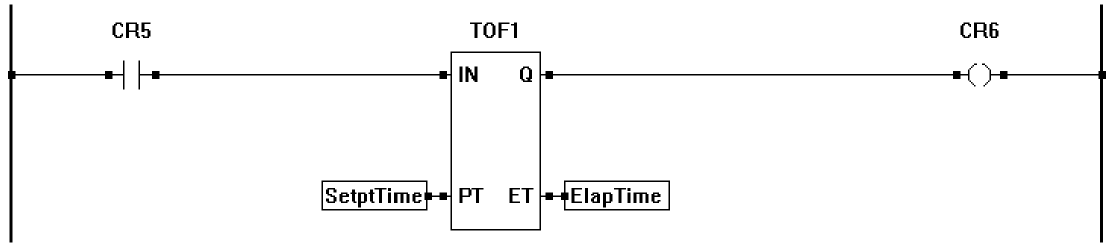
The TOF (off delay timer / time delay on drop-out) is a programmable timer with a variable turn-off time. When the input (IN) input is true, the output (Q) is true. When the input (IN) sees a transition from true to false, the timer begins timing. When the elapsed time (ET) is equal to the preset time (PT), the output (Q) de-energizes (goes false). When the input (IN) sees a false to true to false transition, the timer is reset and begins timing again.

Input / Output Connections:

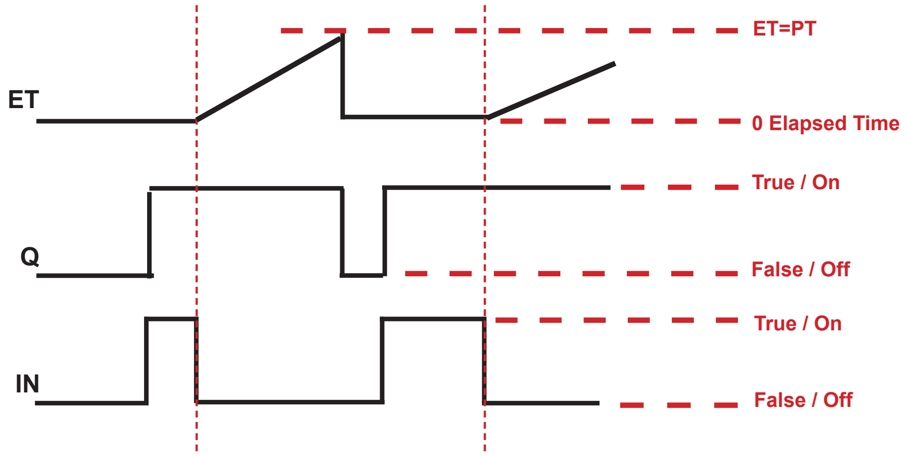
The TOF function block placement requires connections of two input pins (IN, PT) and two output pins (Q, ET).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
IN	Input			X		Falling Edge	
PT	Input				X		
ET					X		
Q	Output			X			

Example Circuit:

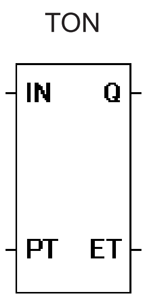


Timing Diagram:



Related Functions: TON, TP

TON



Description:

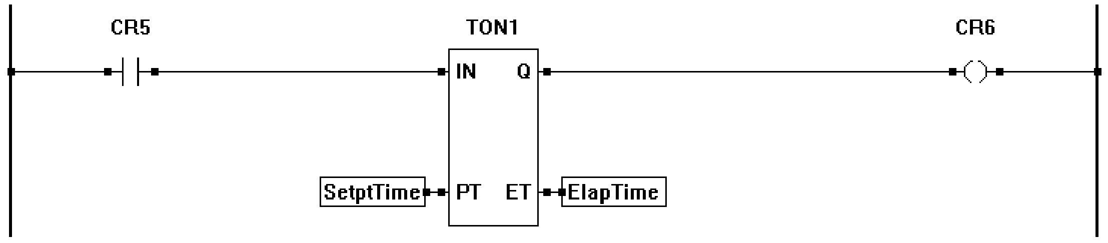
The TON (on delay timer / time delay on pick-up) is a programmable timer with a variable turn-on time. When the input (IN) input is true, the timer begins timing. When the elapsed time (ET) is equal to the preset time (PT), the output (Q) energizes (goes true). When the input (IN) sees a true to false transition, the timer is reset and the output (Q) is de-energized (goes false).

Input / Output Connections:

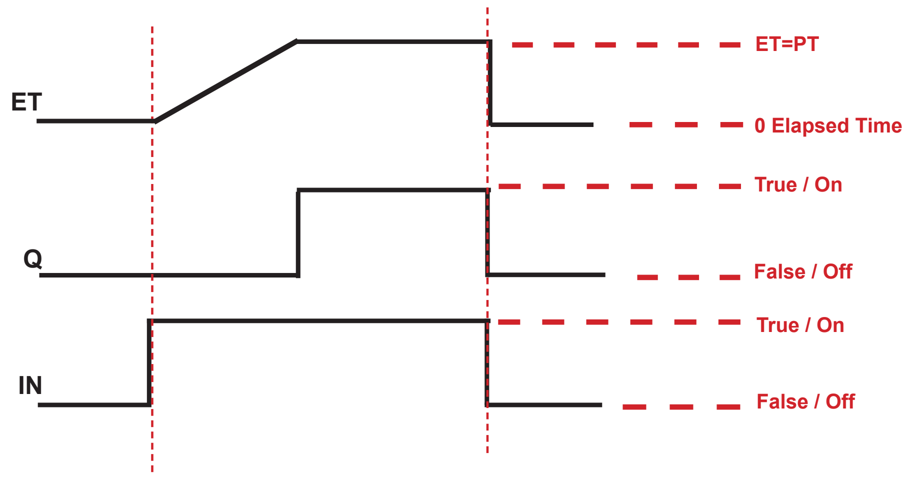
The TON function block placement requires connections of two input pins (IN, PT) and two output pins (Q, ET).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
IN	Input			X		Active True	
PT	Input				X		
ET					X		
Q	Output			X			

Example Circuit:

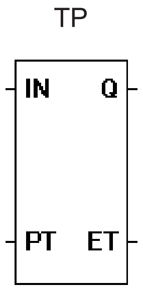


Timing Diagram:



Related Functions: TOF, TP

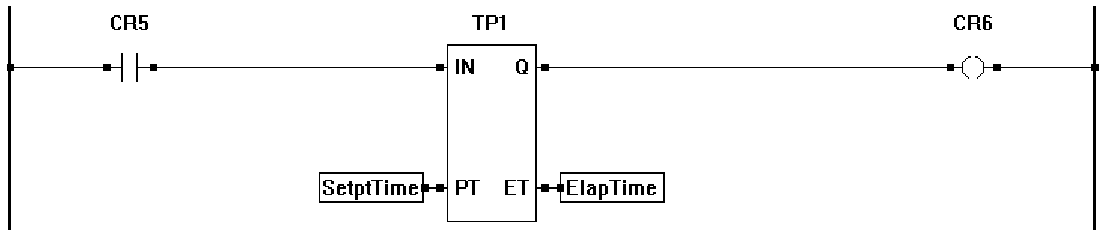
TP

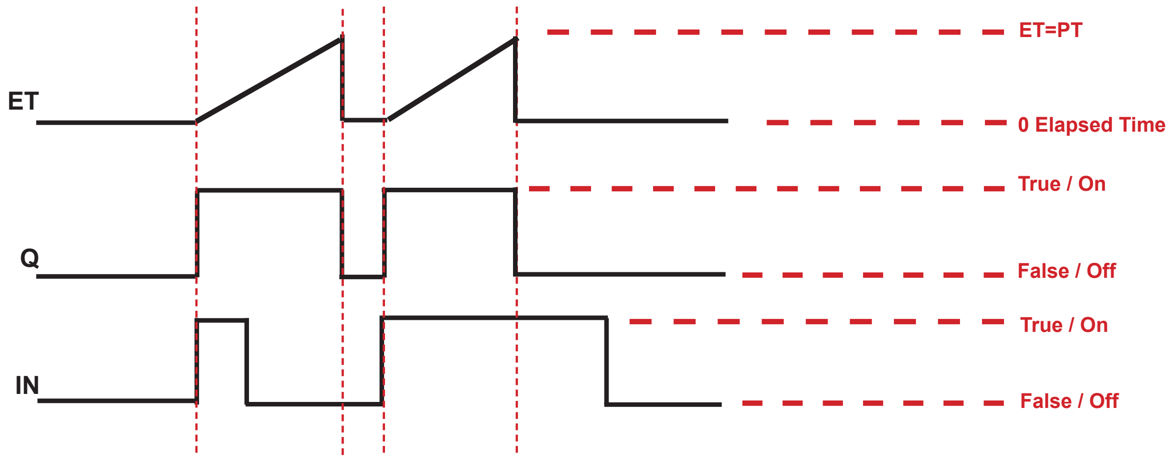


Description:
The TP (pulse timer) is a programmable one-shot timer with a variable turn-on time. When the input (IN) input is true, the timer begins timing and the output (Q) is energized. When the elapsed time (ET) is equal to the preset time (PT), the output (Q) de-energizes (goes false). When the input (IN) goes from true to false, the timer is only reset if the elapsed time (ET) is equal to the preset time (PT). If they are not equal, the reset will not occur until they are equal (and IN must still be false).

Input / Output Connections:
The TP function block placement requires connections of two input pins (IN, PT) and two output pins (Q, ET).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
IN	Input			X		Active True	
PT	Input				X		
ET					X		
Q	Output			X			

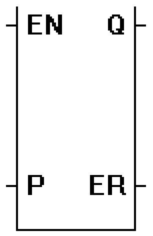
Example Circuit:


Timing Diagram:


Related Functions: TON, TOF

UART_SET_PROPERTY

UART_SET_PROPERTY



Description:

The UART_SET_PROPERTY function block allows for adjustment of certain UART parameters from inside the ladder program. The enable (EN) must be true for the UART_SET_PROPERTY function to be enabled. The Q output is true when the UART_SET_PROPERTY function is enabled. The ER output provides an error code should an error occur. The P is the input parameter to adjust.

A dialog box will automatically open when placing the UART_SET_PROPERTY function block. This dialog allows the selection of the UART and Property to adjust.

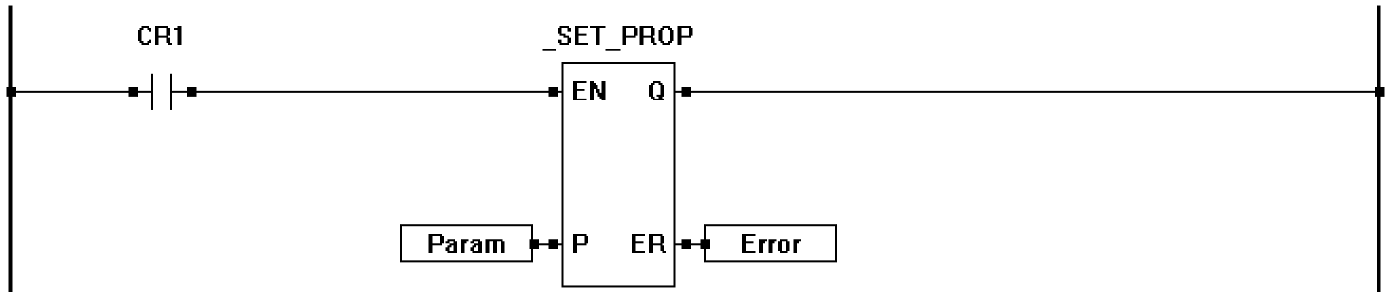
The Baud Rate is the only adjustable parameter as of this release version of EZ LADDER Toolkit.

Input / Output Connections:

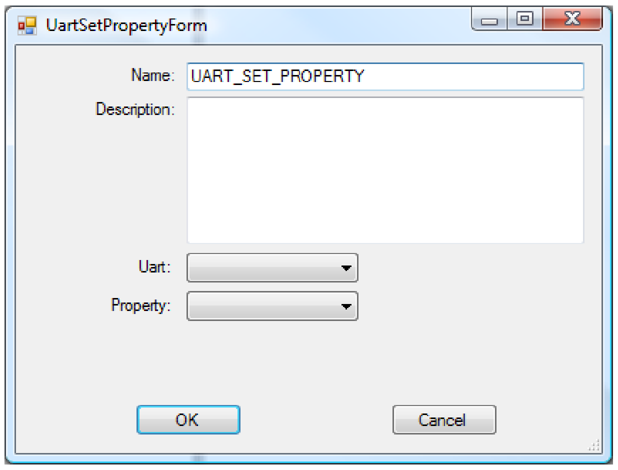
The UART_SET_PROPERTY function block placement requires connections of two input pins (EN, P) and two output pins (Q, ER).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P	Input	X					Parameter
ER		X					Error Out Code, (0) = No Error
Q	Output			X			

Example Circuit:



Dialog Box:



Name: UART_SET_PROPERTY

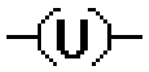
Description:

Uart:

Property:

UNLATCH (COIL)

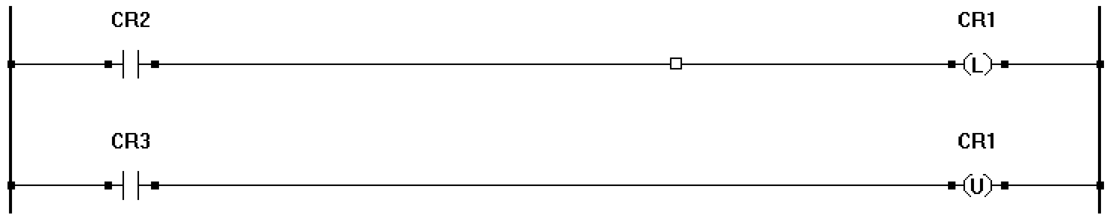
UNLATCH COIL



Description:

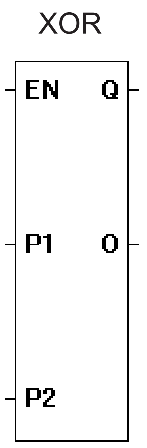
The UNLATCH coil is for use with the LATCH coil operates similar to the DIRECT COIL. The UNLATCH coil will clear it's latched counterpart (LATCH coil with same name). This will cause the LATCH coil to de-energize. LATCH and UNLATCH coils work as pairs. Any boolean variable can be used as a LATCH / UNLATCH coil.

Example Circuit:



Related Functions: LATCH, DIRECT COIL, INVERTED COIL

XOR



Description:

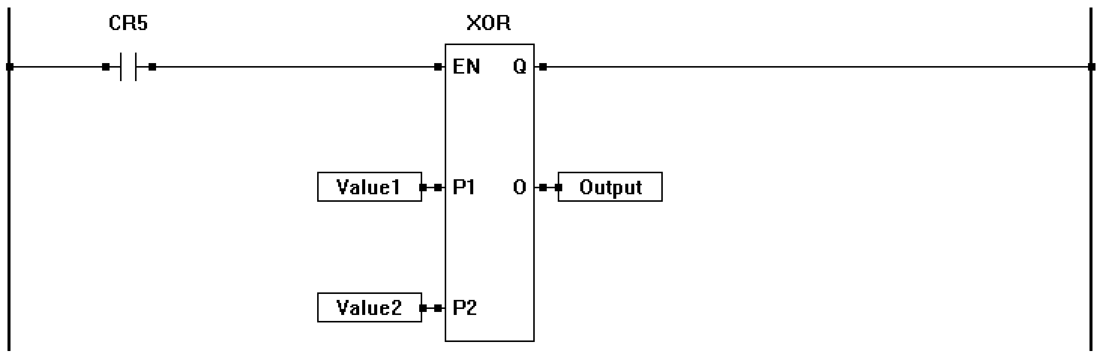
The XOR functions provides a bitwise exclusive OR function of the P1 and P2 inputs. The enable (EN) must be true for the XOR function to be enabled. The Q output is true when the XOR function is enabled.

Input / Output Connections:

The XOR function block placement requires connections of 3 input pins (EN, P1, P2) and two output pins (Q, O).

I/O Pin	Type	Integer	Real	Boolean	Timer	Active State	Other Details
EN	Input			X		Active True	
P1	Input	X					
P2	Input	X					
O	Output	X					
Q	Output			X			

Example Circuit:



Related Functions: OR, AND, NOT

CHAPTER 25

Password Protection

This chapter provides information on securing ladder diagram projects and targets using EZ LADDER Toolkit native password protection.

Chapter Contents

Password Protection Overview

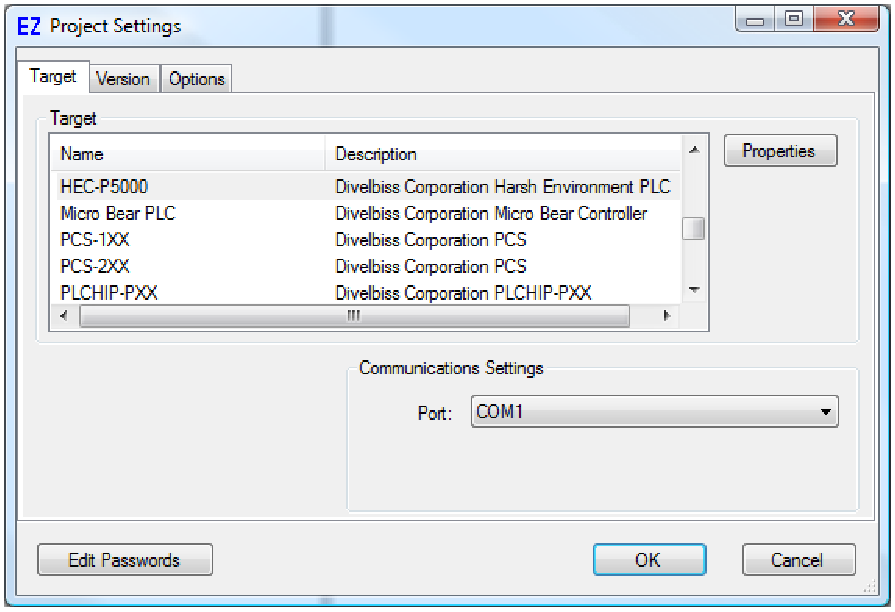
Password protection may be used on all P-Series PLC on a Chip^{TM} targets. There may be multiple passwords for a ladder diagram project. When using Password protection, the Master password is the only pre-named password. Other lower-level passwords and descriptions may be created as needed to provide maximum versatility in allow certain individuals to certain ladder diagram project features.

If password protection is enabled in a ladder diagram project, a password will be required prior to the project opening and being viewed in the EZ LADDER Toolkit Workspace.

Configuring Password Protection

By default, no passwords are set for a new ladder diagram project (.dld). If password protection is desired, the protection must be configured using the Project...Settings Menu.

Select the target (PLCHIP-PXX) and click the **PROPERTIES** button. The *Target Properties* window will open. From the drop-down menu (DCPN), select the model / part number of the target. Click **OK** to save the Target Properties and close the Target Properties Window. You are now back at the Project Settings Window.See Figure 25-1.



Name	Description
HEC-P5000	Divelbiss Corporation Harsh Environment PLC
Micro Bear PLC	Divelbiss Corporation Micro Bear Controller
PCS-1XX	Divelbiss Corporation PCS
PCS-2XX	Divelbiss Corporation PCS
PLCHIP-PXX	Divelbiss Corporation PLCHIP-PXX

Port: COM1

Figure 25-1

In the bottom left corner of the Project Settings window, click the **EDIT PASSWORDS** button. The Password Setup window will open. This window is used to configure the passwords for the ladder diagram project. See Figure 25-2.

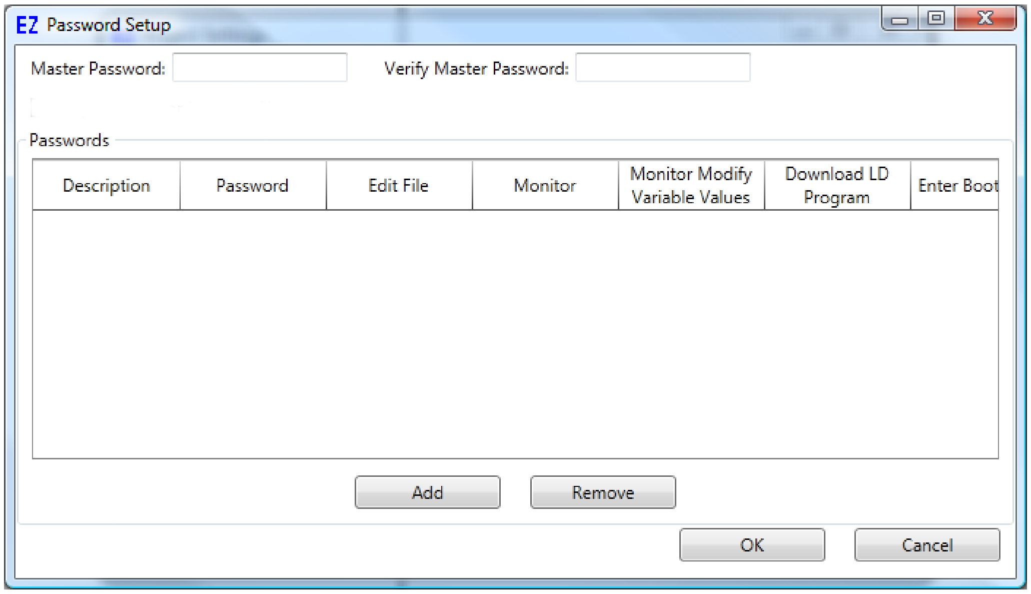


Figure 25-2

Master Password

The Master Password is exactly as phrased. This password is the highest level password in the ladder diagram project. This password should be set and kept closely guarded. When this password is entered, it provides access to all EZ LADDER Toolkit features of the ladder diagram project and allows editing of other level passwords. Enter a master Password in the Master Password box. You will need to re-enter the same password in the Verify Master Password box.

Until the Master Password and Verify Master Password boxes are equal, no other window functions will be functional.

The Master Password should be recorded in a safe place. There is no user-provided way to remove or bypass the Master Password. If you have lost your Master Password, you will need to contact Divelbiss Corporation for options in recovering access to the program.

Once into the Password Setup window, the Master Password can be changed by entering a new password in both the Master Password and the Verify Master Password boxes. It may also be removed by completely clearing both boxes.

If the password Setup is closed by clicking OK, the passwords installed will take effect immediately. Verify you have recorded the Master Password.

Creating Lower-Level Passwords

Additional passwords for lower-level functions may be created. Refer to Figure 25-2.

To add a new password, click the **ADD** button. A new Row in the Passwords section of the Password Setup window will appear. Refer to Figure 25-3

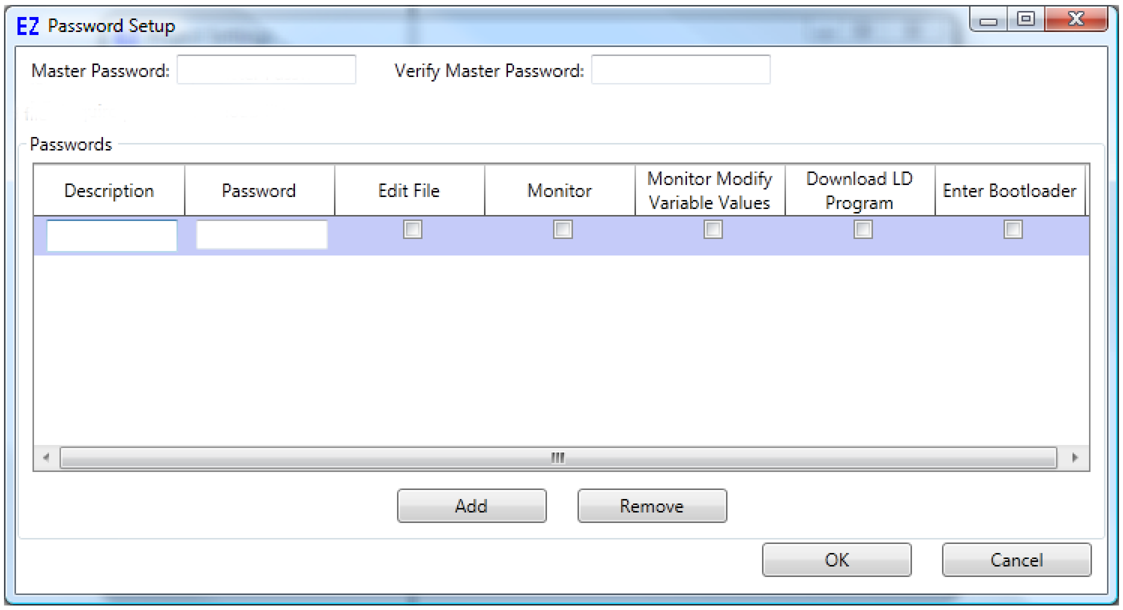


Figure 25-3

Description:	Enter a description for the password's function.
Password:	Enter the password.
Edit File:	When checked, if this password is used, the user will be able to edit the ladder diagram project (ladder diagram).
Monitor:	When checked, if this password is used, the user will be able to monitor the program in EZ LADDER Toolkit (Run mode) and see the program operate in real time.
Monitor Modify Variable Values:	When checked, if this password is used, the user will be able to monitor the program in EZ LADDER Toolkit, see the program operate in real time and be able to modify variable values.
Download LD Program:	When checked, if this password is used, the user will be able to download the ladder diagram program to the hardware target (replacing the current program installed on the hardware target).
Enter Bootloader:	When checked, if this password is used, the user will be able to enter the Bootloader on the hardware target and will allow the user to make any changes normally allowed in the bootloader, including updating the kernel.

Editing Lower-Level Passwords

To edit lower-level passwords, the Master Password is required. When prompted for a password, enter the Master Password. The Password Setup window will be used. Refer to Figure 25-3.

Removing Lower-Level Passwords

To remove lower-level passwords, the Master Password is required. When prompted for a password, enter the Master Password. The Password Setup window will be used. Refer to Figure 25-3.

Passwords may be deleted by highlighting the row in the window (click on the row) and clicking the **REMOVE** button.

CHAPTER 26

Structured Text

This chapter provides information on using Structured Text in EZ LADDER Toolkit.

Chapter Contents

Structured Text Overview

Structured Text is a high level textual language which is an IEC61131-3 language. Structured Text; also called ST is used in EZ LADDER to create custom functions and function blocks. Structured Text syntax resembles PASCAL as it is based on it.

Structured Text is a powerful programming tool to create custom functions and function blocks for items such as serial communication drivers, complex mathematical calculations and many more.

This manual section provides basics on structured text support including supported statements, commands, EZ LADDER specific items and basic syntax and is not a structured text programming manual or tutorial. Other Structured Text sources should be used for a total understanding of how Structured Text is used to accomplish actions. Structured Text is not an intuitive or easy to use language; therefore, it should only be used by those with adequate Structured Text knowledge or experience.

Structured Text Technical Support

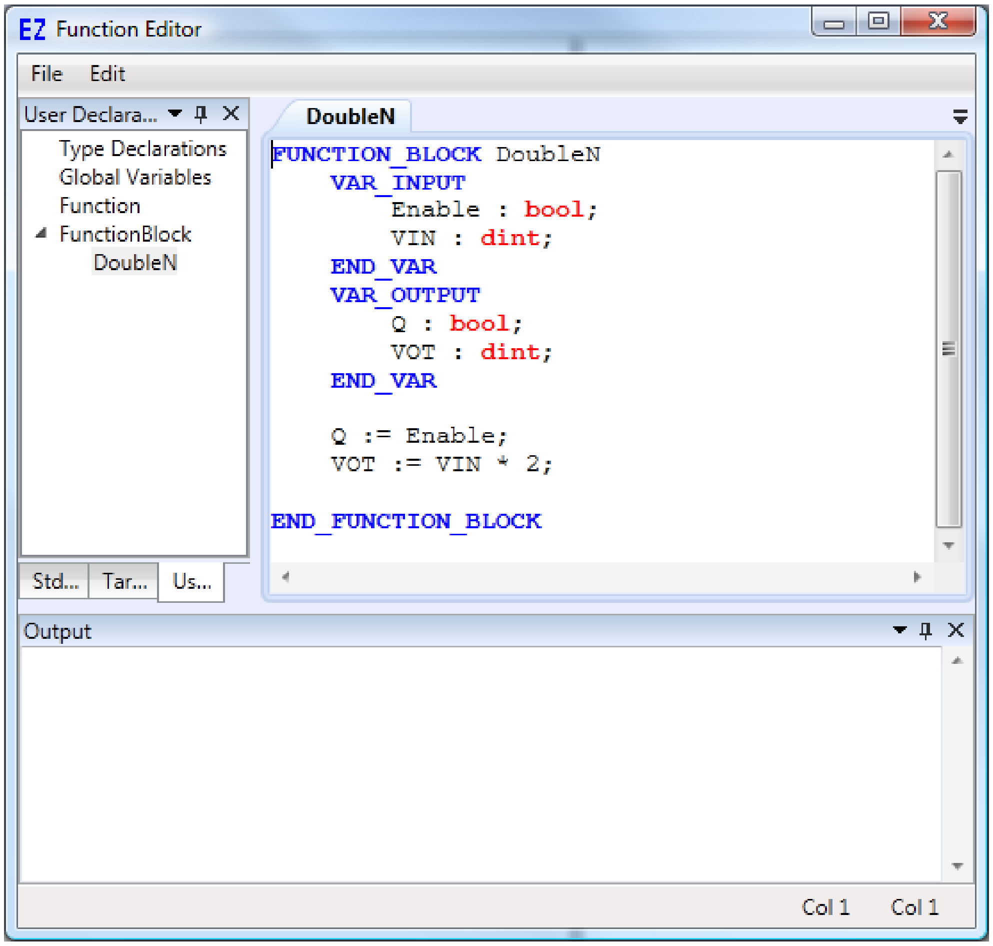
Structured Text technical support for EZ LADDER Toolkit in regards to help with how to create programs, functions and function blocks is limited to e-mail support only. Refer to http://www.divelbiss.com/Support/supt/psupport/ for details on requirements for submitting a structured text support request via e-mail.

Structured Text Introduction

Structured Text is one of the included languages of the IEC-61131 stanard. Using Structured Text, functions and function blocks may be created to perform actions. These functions and function blocks are designed to operate with other programming languages and therefore may 'call' other functions or function blocks and may also be 'called' from the main ladder diagram, other function or function block. If you are familiar with other high level languages such as C, Structured Text (ST) programming will be similar.

Each program, function and function block begin and end with their respective statements. Between the statments, is where all the variables are declared and the actual actions are taken using other commands and statements such as For...Next, etc. Figure 26-1 is a sample of a custom function block using structured text.

One of the important differences between other programming languages and Structured Text is program flow. It is possible to program Structured Text so that it will loop indefinately, giving undesired results and operation.



```
FUNCTION_BLOCK DoubleN
    VAR_INPUT
        Enable : bool;
        VIN : dint;
    END_VAR
    VAR_OUTPUT
        Q : bool;
        VOT : dint;
    END_VAR

    Q := Enable;
    VOT := VIN * 2;

END_FUNCTION_BLOCK
```

Figure 26-1 - ST Function Editor

The example shown in Figure 26-1 is the ST code for a function block named ***DoubleN***. This block's purpose is to take an integer input, double it and then output the result.

As shown, the ST language is composed of statements separated by seimcolons. These statements and subroutines are used to change variables defined. These defined variables may be defined values such as constants, internally stored variables, input and outputs. Spaces are used to separate variables from statements. Semcolons are used to signify the end of most code lines (as shown in Figure 26-1).

As shown in Figure 26-1, it is good form to indent variable declarations and subroutines. This allows easier reading and scanning of the line of code for debugging purposes.

Structured Text Variables

Structured Text programming requires named variables to be defined. Variable names must begin with a letter with the remaining name being any combinations of letters, numbers and some symbols (such as '_'). While variable names are not case sensitive, the use of case can be helpful for readability.

Certain variable names are reserved and cannot be used. Names of functions, function blocks, statements and others items are not allowed as variable names.

Examples of invalid variable names would be IF, EXP, etc. If an incorrect variable name is used, an error should occur during the code 'Verify'.

Variable Declarations

The variable declaration statements in figure 26-2 may be used to declare variables and name them in a *callable* structured text function or function block. Certain declarations are limited based on the type of *callable* ST code (if function or function block). **Callable in this instance refers to if the function or function block will be called from the ladder diagram and only applies to the input / output variable declarations**. ST functions (function blocks) called from other ST functions (function blocks) do not have these limitations.

Declaration	Description	Use with ST_FUNC	Use with ST_FUN_BLK
VAR	A general variable declaration. Used for internal function (block) declarations. Keeps variable values from call to call.		X
VAR_INPUT	Defines variables that are treated as inputs to the function (block). These values are passed into the function (block) from an external source.	X	X
VAR_OUTPUT	Defines variables that are treated as outputs to other functions (blocks). These values are passed to other external items (function, etc).	X	X
VAR_EXTERNAL	Used to access variables from the ladder diagram or variables declared under the 'Global' user declarations.		X
VAR_TEMP	A general variable declaration. Used for internal function (block) declarations. Does not keep variable values from call to call.		X
VAR_IN_OUT	Defines variables that are treated as both inputs and outputs to other functions (blocks). These values are received from and passed to other external items (function, etc).		X

Figure 26-2 - Variable Declarations as Input/Output of Callable Function or Function Block

For the variable declarations listed in Figure 26-2, additional restrictions apply depending whether the ST code is a function or a function block. Figure 26-3 lists the type of actual variables that may be used in a ladder diagram *callable* function (function block) when used with VAR_IN, VAR_OUT or VAR_IN_OUT declarations (input / outputs to function or function block). Internal variable declarations are not limited.

Variable Data Type	Description	Use with ST_FUNC	Use with ST_FUN_BLK
BOOL	Boolean value (0,1, True, False)	X	X
DINT	Double Integer (32 bit)	X	X
REAL	Float (real) number with decimal point	X	X

Figure 26-3 - Variable Data Type for Input/Output Declarations of Callable Functions & Function Blocks

Only the variable data types listed in Figure 26-3 may be used in ladder diagram callable functions or function blocks as variable declaration types for input or output (VAR_IN, VAR_OUT, VAR_IN_OUT). The use of other data types for input or output variable declarations will result in the function or function block not appearing in the selection menu for inserting the function or function block into the ladder diagram. Other variable data types may be used internally to the function or function block.

As shown in 26-1, all variable declarations begin with the VAR (see Figure 26-2) statement to identify the beginning of the variable declaration and end with the VAR_END statement to identify where the variable declaration ends.

All the previous Figures and examples have illustrated the variable declarations and data types that are supported for the inputs and outputs of callable functions and function blocks. Other data types are supported for functions and function blocks provided they are internal to the function or function block and are not declared as an Input or Output.

Supported Variable Data Types

The variable types listed in Figure 26-4 are supported in EZ LADDER Toolkit Structured Text. Some limitations apply depending upon the type of function or function block and the type of variable declaration.

Keyword	Data Type	Bit Size	Internal Data Type	Input/Output Data Type
BOOL	Boolean	1	X	X
SINT	Short Integer	8	X	
INT	Integer	16	X	
DINT	Double Integer	32	X	X
LINT	Long Integer	64	X	
USINT	Unsigned Short Integer	8	X	
UINT	Unsigned Integer	16	X	
UDINT	Unsigned Double Integer	32	X	
ULINT	Unsigned Long Integer	64	X	
REAL	Real Numbers	32	X	X
LREAL	Long Real Numbers	64	X	
BYTE	Bit String of length 8	8	X	
WORD	Bit String of length 16	16	v	
DWORD	Bit String of length 32	32	X	
LWORD	Bit String of length 64	64	X	
ARRAY [..] OF	Array ot Type	---	X	

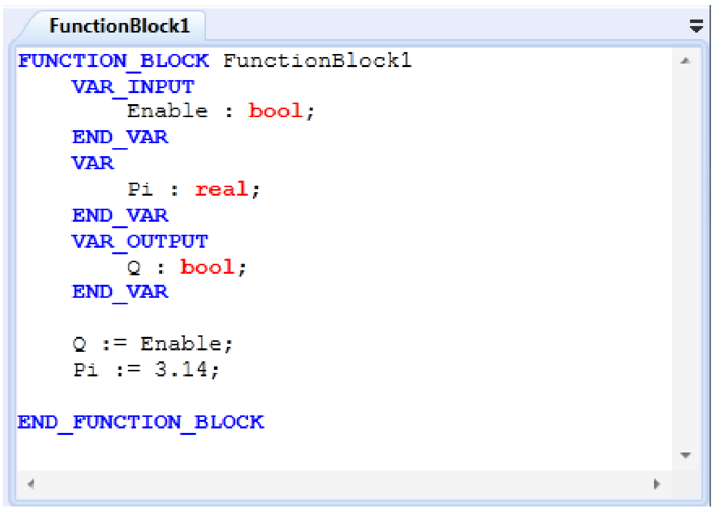
Figure 26-4 Supported Data Types

Structured Text Language

Structured Text (ST) language is uses a combination of assignments, expressions, construct statements, variables and comments to form function or function blocks.

Assignments are used in ST to assign values to tags (variables). Assignments use the operator := (colon and equal signs).

In Structured Text, to set a Variable named Pi to 3.14, see Figure 26-5.



FunctionBlock1

```
FUNCTION_BLOCK FunctionBlock1
    VAR_INPUT
        Enable : bool;
    END_VAR
    VAR
        Pi : real;
    END_VAR
    VAR_OUTPUT
        Q : bool;
    END_VAR

    Q := Enable;
    Pi := 3.14;

END_FUNCTION_BLOCK
```

Figure 26-5

Expressions may be part of an assignment or construct statement. An expression evalutes to a number (numerical expression, INT, REAL) or to a true or false condition (BOOL). An expression may contain variables, constants, operators and functions. Refer to Figure 26-6.

Expression Contains	Description / Definition	Example
Variables	Variable where data is stored inside the function (BOOL, INT, DINT, REAL)	**Pi**
Constants	A hard coded constant value	**6**
Operators	A symbol that specifies a operation within an expression (+, -, *, /)	**Vb1 + Vb2**
Functions	When executed, a function call returns a single value. Parenthesis are used to contain the operand of a function call. Functions can be used in expressions while instructions cannot.	**functionname (vbl)**

Figure 26-6

Instructions are standalone statements that when executed, povies one or more values that are part of it's data structure. Instructions are terminated with a semi colon (;). Instructions cannot be used in expressions.

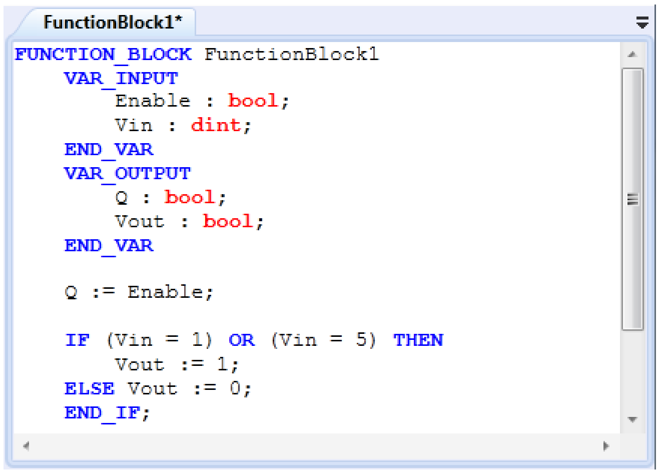
A typical instruction would appear as: *instruction (operand1, operatnd2...);*

Constructs are conditional statements used to trigger additional structure text code depending upon the evaluation of a condition. Conditional statements are terminated with a semi colon (;).

Typically used constructs:

IF...THEN	CASE	FOR...DO
WHILE...DO	REPEAT...UNTIL	EXIT

Figure 26-7 is a sample of using a construct in a function block.

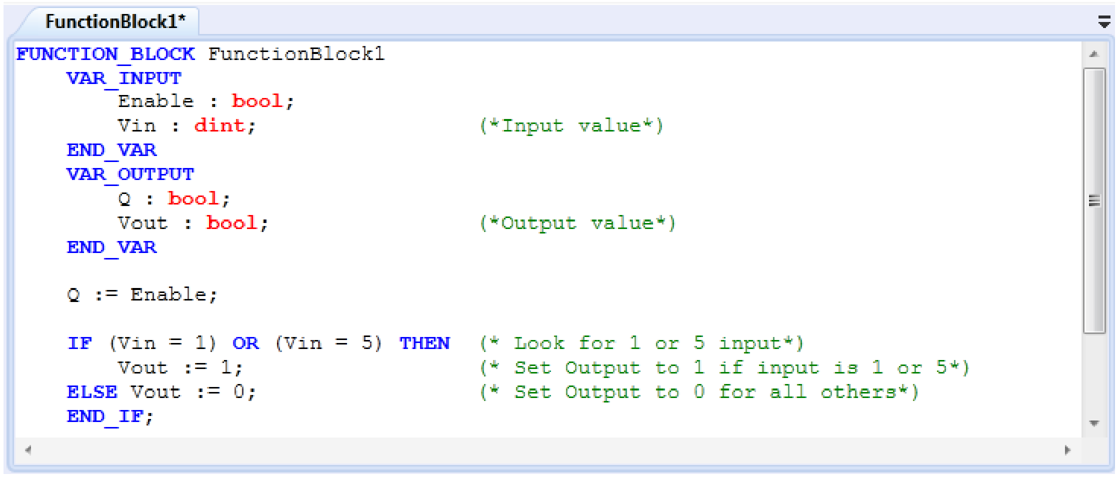


```
FUNCTION_BLOCK FunctionBlock1
    VAR_INPUT
        Enable : bool;
        Vin : dint;
    END_VAR
    VAR_OUTPUT
        Q : bool;
        Vout : bool;
    END_VAR

    Q := Enable;

    IF (Vin = 1) OR (Vin = 5) THEN
        Vout := 1;
    ELSE Vout := 0;
    END_IF;
```

Figure 26-7

Comments are used in a function or function block to explain, clarify and document what a section of structured text does and any information the programmer wants to include. Comments are helpful when revisiting code in a function or function block.

Comments may appear anywhere in the structured text and have no effect on the structured text execution. Comments are identified in structured text by the use of parenthesis and astericks (* or *). Figure 26-8 is an example of adding comments to a function block.



```
FUNCTION_BLOCK FunctionBlock1
    VAR_INPUT
        Enable : bool;
        Vin : dint;                (*Input value*)
    END_VAR
    VAR_OUTPUT
        Q : bool;
        Vout : bool;               (*Output value*)
    END_VAR

    Q := Enable;

    IF (Vin = 1) OR (Vin = 5) THEN  (* Look for 1 or 5 input*)
        Vout := 1;                  (* Set Output to 1 if input is 1 or 5*)
    ELSE Vout := 0;                 (* Set Output to 0 for all others*)
    END_IF;
```

Figure 26-8

Arithemtic Operators & Functions

A major advantage to programming in structured text is the ability to make custom functions or function blocks that include complex calculations and mathematical features. Structured text supports many arithmetic operators and standard functions for creating these complex calcuations.

Figure 26-9 lists the standard arithmetic operators supported by EZ LADDER Toolkit's function ST Editor. Although not shown, a semi colon (;) ends each operator line. Parethesis should be used to control order of operation.

To	Operator	Example
Add	+	X := A1 + A2 + A3....
Subract	-	X := A1 - A2
Multiply	*	X := A1 * A2 * A3....
Exponent (x^y)	EXPT	X := A1**A2
Divide	/	X := A1 / A2
Modulo-divide	MOD	X := A1 MOD A2

Figure 26-9

The arithmetic functions in Figure 26-10 are supported by EZ LADDER Toolkit's Structured Text.

Function	Description	Syntax
ABS	Absolute Value of a numeric expression.	ABS (*numeric_expression*)
ACOS	Arc Cosine of a numeric expression.	ACOS (*numeric_expression*)
ASIN	Arc Sine of a numeric expression.	ASIN (*numeric_expression*)
ATAN	Arc Tangent of a numeric expression	ATAN (*numeric_expression*)
COS	Cosine of a numeric expression	COS (*numeric_expression*)
EXP	Exponential of a numeric expression.	EXP (*numeric_expression*)
EXPT	Exponent of two numerical expressions.	EXPT *(num_exp1, num_exp2)*
LN	Natural Log of a numeric expression	LN (*numeric_expression*)
LOG	Log Base 10 of a numeric expression	LOG (*numeric_expression*)
SIN	Sine of a numeric expression	SIN (*numeric_expression*)
SQRT	Square Root of a numeric expression	SQRT (*numeric_expression*)
TAN	Tangent of a numeric expression	TAN (*numeric_expression*)
TRUNC	Truncate a numerical expression.	TRUNC (*numeric_expression*)

Figure 26-10

Relational Operators

Relational operator compare two values (strings or numerical expressions) and provide a true or false result based on the comparison. The result of a relational operator is always a true or false (BOOL, 0 or 1).

Figure 26-11 lists the supported relational operators for EZ LADDER Toolkit's Structured Text.

Operator	Description	Example
=	Equal to.	IF X = 1 THEN...
<	Less Than	IF X < 25 THEN..
<=	Less Than or Equal to	IF X <=15 THEN..
>	Greater Than	IF X > 5 THEN..
>=	Greater Than or Equal to	IF X >= 100 THEN..
<>	Not Equal to	IF X <> 6 THEN..

Figure 26-11

Logical Operators

Logical operators are used to compare if multiple conditions are true or false. The result of a logical operator is always a true or false (BOOL, 0 or 1). These operators are helpful in determining a status of multiiple items and performing an action based on that status. Figure 26-12 lists the supported logical operators in EZ LADDER Toolkit's Structured Text. Parenthesis should be used to control logical flow.

Operator	Description	Example
AND	Logical AND	IF X = 1 AND Y = 2 THEN...
OR	Logical OR	IF X = 2 OR X=4 THEN..
XOR	Logical Exclusive OR	IF XOR (A,B) = 1 THEN..
NOT	Logical Complement	IF NOT(A) = 1 THEN..

Figure 26-12

The combination of aritmetic, relational and logic operators allow for complex control of multiple inputs and outputs in a control scheme.

Bitwise Operators

Bitwise operators are used to manipulate bits within values based on two additional values. Different from logical operators, bitwise operators actually compare the bits of the number and not the entire number. The results will differ.

Operator	Description	Example
AND	Bitwise AND	Z := X AND Y
OR	Bitwise OR	Z := X OR Y
XOR	Bitwise Exclusive OR	Z := A XOR B
NOT	Bitwise Complement	Z := NOT B

Figure 26-13

Order of Execution

Operation written into structured text expressions are performed in a prescribed order. This order may be from left to right, but not always, depending upon the operators and language used.

Operations that have equal order will be performed left to right.

When writing expressions with multiple operations and functions, it is ideal to use parenthesis to group the condtions. This will control the order (or flow) of execution and also makes it easier to read and understand the expression.

Standard Functions

Figure 26-14 lists the supported EZ LADDER Toolkit's Structured Text standard functions. These functions are standard in structured text and conform to the IEC-61131-3 standard.

Function	Function	Function	Function	Function
BYTE_TO_DINT	INT_TO_LINT	LSB_UINT_TO_ARRAY	ROL	UDINT_TO_LINT
BYTE_TO_DWORD	INT_TO_LREAL	LSB_ULINT_TO_ARRAY	ROR	UDINT_TO_LREAL
BYTE_TO_INT	INT_TO_LWORD	LSB_WORD_TO_ARRAY	SEL	UDINT_TO_LWORD
BYTE_TO_LINT	INT_TO_REAL	LWORD_TO_BYTE	SHL	UDINT_TO_REAL
BYTE_TO_LREAL	INT_TO_SINT	LWORD_TO_DINT	SHR	UDINT_TO_SINT
BYTE_TO_LWORD	INT_TO_UDINT	LWORD_TO_DWORD	SIN	UDINT_TO_UINT
BYTE_TO_REAL	INT_TO_UINT	LWORD_TO_INT	SINT_TO_BYTE	UDINT_TO_ULINT
BYTE_TO_SINT	INT_TO_ULINT	LWORD_TO_LINT	SINT_TO_DINT	UDINT_TO_USINT
BYTE_TO_UDINT	INT_TO_USINT	LWORD_TO_LREAL	SINT_TO_DWORD	UDINT_TO_WORD
BYTE_TO_UINT	INT_TO_WORD	LWORD_TO_REAL	SINT_TO_INT	UINT_TO_BYTE
BYTE_TO_ULINT	LEFT	LWORD_TO_SINT	SINT_TO_LINT	UINT_TO_DINT
BYTE_TO_USINT	LEN	LWORD_TO_UDINT	SINT_TO_LREAL	UINT_TO_DWORD
BYTE_TO_WORD	LIMIT	LWORD_TO_UINT	SINT_TO_LWORD	UINT_TO_INT
CONCAT	LINT_TO_BYTE	LWORD_TO_ULINT	SINT_TO_REAL	UINT_TO_LINT
DELETE	LINT_TO_DINT	LWORD_TO_USINT	SINT_TO_UDINT	UINT_TO_LREAL
DINT_TO_BYTE	LINT_TO_DWORD	LWORD_TO_WORD	SINT_TO_UINT	UINT_TO_LWORD
DINT_TO_DWORD	LINT_TO_LREAL	MAX	SINT_TO_ULINT	UINT_TO_REAL
DINT_TO_INT	LINT_TO_LWORD	MID	SINT_TO_USINT	UINT_TO_SINT
DINT_TO_LINT	LINT_TO_REAL	MIN	SINT_TO_WORD	UINT_TO_UDINT
DINT_TO_LREAL	LINT_TO_SINT	MSB_DINT_TO_ARRAY	TO_LSB_DINT	UINT_TO_ULINT
DINT_TO_LWORD	LINT_TO_UDINT	MSB_DWORD_TO_ARRAY	TO_LSB_DWORD	UINT_TO_USINT
DINT_TO_REAL	LINT_TO_UINT	MSB_INT_TO_ARRAY	TO_LSB_INT	UINT_TO_WORD
DINT_TO_SINT	LINT_TO_ULINT	MSB_LINT_TO_ARRAY	TO_LSB_LINT	ULINT_TO_BYTE
DINT_TO_UDINT	LINT_TO_USINT	MSB_LREAL_TO_ARRAY	TO_LSB_LREAL	ULINT_TO_DINT
DINT_TO_ULINT	LINT_TO_WORD	MSB_LWORD_TO_ARRAY	TO_LSB_LWORD	ULINT_TO_DWORD
DINT_TO_USINT	LREAL_TO_BYTE	MSB_REAL_TO_ARRAY	TO_LSB_REAL	ULINT_TO_INT
DINT_TO_DWORD	LREAL_TO_DINT	MSB_UDINT_TO_ARRAY	TO_LSB_UDINT	ULINT_TO_LINT
DWORD_TO_BYTE	LREAL_TO_DWORD	MSB_UINT_TO_ARRAY	TO_LSB_UINT	ULINT_TO_LREAL
DWORD_TO_DINT	LREAL_TO_INT	MSB_ULINT_TO_ARRAY	TO_LSB_ULINT	ULINT_TO_LWORD
DWORD_TO_INT	LREAL_TO_LINT	MSB_WORD_TO_ARRAY	TO_LSB_WORD	ULINT_TO_REAL
DWORD_TO_LINT	LREAL_TO_LWORD	MUX	TO_MSB_DINT	ULINT_TO_SINT
DWORD_TO_LREAL	LREAL_TO_SINT	REAL_TO_BYTE	TO_MSB_DWORD	ULINT_TO_UDINT
DWORD_TO_LWORD	LREAL_TO_UDINT	REAL_TO_DINT	TO_MSB_INT	ULINT_TO_UINT
DWORD_TO_REAL	LREAL_TO_UINT	REAL_TO_DWORD	TO_MSB_LINT	ULINT_TO_USINT
DWORD_TO_SINT	LREAL_TO_ULINT	REAL_TO_INT	TO_MSB_LREAL	ULINT_TO_WORD
DWORD_TO_UDINT	LREAL_TO_USINT	REAL_TO_LINT	TO_MSB_LWORD	USINT_TO_BYTE
DWORD_TO_UINT	LREAL_TO_WORD	REAL_TO_LWORD	TO_MSB_REAL	USINT_TO_DINT
DWORD_TO_ULINT	LSB_DINT_TO_ARRAY	REAL_TO_SINT	TO_MSB_UDINT	USINT_TO_DWORD
DWORD_TO_USINT	LSB_DWORD_TO_ARRAY	REAL_TO_UDINT	TO_MSB_UINT	USINT_TO_INT
DWORD_TO_WORD	LSB_INT_TO_ARRAY	REAL_TO_UINT	TO_MSB_ULINT	USINT_TO_LINT
FIND	LSB_LINT_TO_ARRAY	REAL_TO_ULINT	TO_MSB_WORD	USINT_TO_LREAL
INSERT	LSB_LREAL_TO_ARRAY	REAL_TO_USINT	UDINT_TO_BYTE	USINT_TO_LWORD
INT_TO_BYTE	LSB_LWORD_TO_ARRAY	REAL_TO_WORD	UDINT_TO_DINT	USINT_TO_REAL
INT_TO_DINT	LSB_REAL_TO_ARRAY	REPLACE	UDINT_TO_DWORD	USINT_TO_SINT
INT_TO_DWORD	LSB_UDINT_TO_ARRAY	RIGHT	UDINT_TO_INT	USINT_TO_UDINT

Function	Function	Function	Function
USINT_TO_UINT	WORD_TO_DINT	WORD_TO_LREAL	WORD_TO_UDINT
USINT_TO_ULINT	WORD_TO_DWORD	WORD_TO_LWORD	WORD_TO_UINT
USINT_TO_WORD	WORD_TO_INT	WORD_TO_REAL	WORD_TO_ULINT
WORD_TO_BYTE	WORD_TO_LINT	WORD_TO_SINT	WORD_TO_USINT

Figure 26-14

Constructs & Statements

Figure 26-15 lists the supported EZ LADDER Toolkit's Structured Text constructs and statements.

Construct / Statement	Structure
IF...THEN / ELSIF...THEN / ELSE	IF_statement ::= 'IF' expression 'THEN' statement_list {'ELSIF' expression 'THEN' statement_list} ['ELSE' statement_list] 'END_IF'
CASE...OF / ELSE	CASE_statement ::= 'CASE' expression 'OF' case_element {case_element} ['ELSE' statement_list] 'END_CASE'
FOR / WHILE / REPEAT / EXIT	FOR_statement ::= 'FOR' control_variable ':=' for_list 'DO' statement_list 'END_FOR' control_variable ::= identifier FOR_LIST ::= expression 'TO' expression ['BY' expression] WHILE_statement ::= 'WHILE' expression 'DO' statement_list 'END_WHILE' REPEAT_statement ::= 'REPEAT' statement_list 'UNTIL' expression 'END_REPEAT' EXIT_statement ::= 'EXIT'

Figure 26-15

Structured Text Function Blocks

EZ LADDER Toolkit provides two types of function blocks that use structured text: ST_FUNC and ST_FUN_BLK. These two function blocks are similar is some ways but different in others.

These blocks may be callable; referring to the function blocks may be inserted into a ladder diagram project and the ladder diagram *call* or cause the structured text to operate inside the function block based on the inputs to the block. Certain rules must be followed for a function block (either ST_FUNC or ST_FUNC_BLK) may be used as a callable function (block).

ST_FUNC Function (Function Block)

The ST_FUNC function block is used to place a ST User-Defined function into a ladder diagram. When the ST_FUNC function block is placed, a drop-down menu is used to select the functions from the User-Defined Functions (created by you in the ST Editor).

To place a ST_FUNC, use the drop-down function block menu in the toolbar just as any other ladder function / function block. Select ST_FUNC and click to place it in the ladder where it is required.

Structured text user-defined functions differ from functionblocks. When a function's instance is called, it executes and internal variables are used only for that instance and call. Variable values are not kept from one execution (or scan) to another while functionblocks pass their variables from one execution (scan) to another making them ideal when variables would need to be passed from scan to scan such as a count.

For a user-defined function to be usable as a callable function (inserted in the ladder diagram), it must mee the following criteria:

- Return Type must be a BOOL.
- May only contain input/output variable declarations: VAR_INPUT, VAR_OUTPUT
- Variable Input/Output types may only be BOOL, DINT or REAL. Internal variables may be any sup-porte type.

ST_FUNC_BLK Function Block

The ST_FUNC_BLK function block is used to place a ST User-Defined functionblock into a ladder diagram. When the ST_FUNC_BLK function block is placed, a drop-down menu is used to select the functionsblock from the User-Defined Functionsblocks (created by you in the ST Editor).

To place a ST_FUNC_BLK, use the drop-down function block menu in the toolbar just as any other ladder function / function block. Select ST_FUNC_BLK and click to place it in the ladder where it is required.

Structured text user-defined functions differ from functionblocks. When a function's instance is called, it executes and internal variables are used only for that instance and call. Variable values are not kept from one execution (or scan) to another while functionblocks pass their variables from one execution (scan) to another making them ideal when variables would need to be passed from scan to scan such as a count.

For a user-defined functionblock to be usable as a callable function (inserted in the ladder diagram), it must mee the following criteria:

- First Output type must be a BOOL.
- May only contain input / output variable declarations: VAR_INPUT, VAR_OUTPUT, VAR, VAR_EX-TERNAL, VAR_TEMP
- Variable Input/Output types may only be BOOL, DINT or REAL. Internal variables may be any sup-ported type.

Target Specific ST Functions

Target specific ST Functions refers to functions in addition to the stardard functions listed earlier that are required interact with specific features on the actual hardware target, such as Uarts, SPI ports, etc. These functions are provided by Divelbiss Corporation as part of EZ LADDER Toolkit and cannot be edited, deleted or added to exept by Divelbiss.

File Descriptors

Many of the target specific functions require a *File Descriptor* that acts as a device locator that the structured text uses to locate the specific resource. They listed in the table as *FD_x*. For example, to use the EZ_EE-PromReadArray, you must have the file descriptor for the actual EEPROM that is the device to read from.

The file descriptors for devices may be found in the Structured Text Editor. Click the Variables tab at the bottom left. All devices listed under FD_ are actual file descriptors. Refer to Figure 26-16. With an open function block to edit, double-clicking on any variable including file descriptors (FD_) will insert the it into the cursors location in the function block.

Only devices installed in the Project Settings will appear. If the device does not appear, check the Project Settings and install the device.

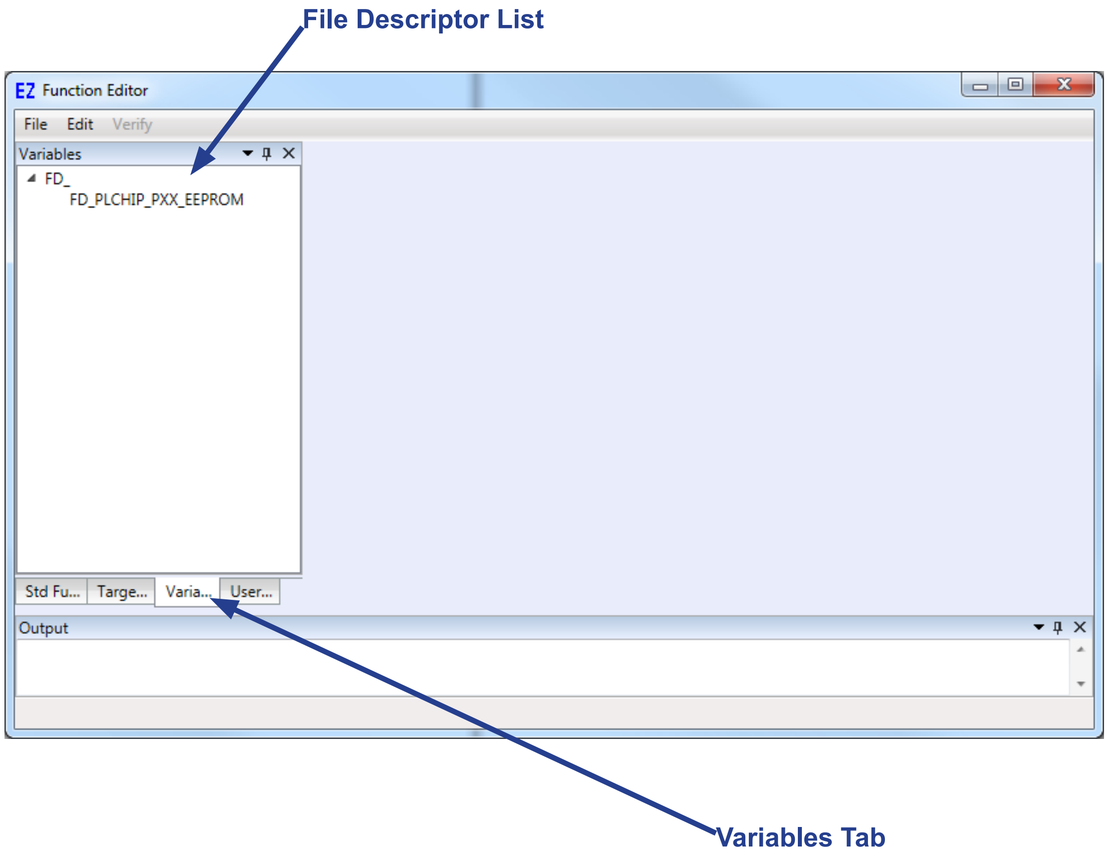


Figure 26-16

The following table lists the target specific ST functions and descriptions of each.

Target Specific Function	Description / Details	
EZ_GetTickCount	Description	Gets the current Tick count from the PLC on a Chip
	Format:	UDINTvar := EZ_GetTickCount();
	Parameters	n/a
	Return	# of milliseconds elapsed system system started.
EZ_EEPromRead	Description	Reads Data from EEPROM memory.
	Format:	DINTvar := EZ_EEPromRead(FD_x, StartAdr, Datavar);
	Parameters	FD_x = File Descriptor StartAdr = EEPROM address to start reading from (DINT) Datavar = Variable to hold read data (any variable type)
	Return	# of bytes read (dependent upon type of variable used for Datavar)
EZ_EEPromReadArray	Description	Reads Data array from EEPROM memory.
	Format:	DINTvar := EZ_EEPromReadArray(FD_x, StartAdr, Buffer, offset, len);
	Parameters	FD_x = File Descriptor StartAdr = EEPROM address to start reading from (DINT) Buffer = Destination buffer to hold read EEPROM contents (ARRAY[ ] of USINT) offset = Offset into the Buffer where to start writing read data. (DINT) len = # of bytes to read (DINT)
	Return	# of bytes read
EZ_EEPromWrite	Description	Writes Data to EEPROM memory.
	Format:	DINTvar := EZ_EEPromWrite(FD_x, StartAdr, Datavar);
	Parameters	FD_x = File Descriptor StartAdr = EEPROM address to start writing to (DINT) Datavar = Variable of data to be written (any variable type)
	Return	# of bytes written (dependent upon type of variable used for Datavar)
EZ_EEPromWriteArray	Description	Writes Data array to EEPROM memory.
	Format:	DINTvar := EZ_EEPromWriteArray(FD_x, StartAdr, Buffer, offset, len);
	Parameters	FD_x = File Descriptor StartAdr = EEPROM address to start writing to (DINT) Buffer = Source buffer for write data (ARRAY[ ] of USINT) offset = Offset into the Buffer where to start reading write data. (DINT) len = # of bytes to read (DINT)
	Return	# of bytes read
EZ_FormatString	Description	Formats a string similar to standard 'C' PrintF (also used in LCD / Serial Print)
	Format:	DINTvar := EZ_FormatString(Strbuffer, string format, ...);
	Parameters	Strbuffer = Destination of where the formatting string is stored string format = String format to use (PrintF) ... = additional arguments (depends on string format)
	Return	# of bytes written to buffer
EZ_GPIO_Init	Description	Configures a GPIO pin from structured text as an input pin or an output pin.
	Format:	BOOLvar: =EZ_GPIO_INIT(GPIOnum, PinSel, Mode)
	Parameters	GPIOnum = Number of GPIO pin to configure. (UDINT) PinSel = 16#100 for digital input or 16#200 for digital output (UDINT) Mode = 1 for pull down or 2 = pull up (internal P13 Chip resistance) (UDINT)
	Return	True is configuration is successful.

Target Specific Function	Description / Details	
EZ_GPIO_Read	Description	Reads the current status of a digital input.
	Format:	BOOLvar:=EZ_GPIO_Read(GPIOnum) (UDINT)
	Parameters	GPIOnum = Number of GPIO pin to read status
	Return	Returns digital input state as true or false
EZ_GPIO_Write	Description	Sets the state of a digital output.
	Format:	EZ_GPIO_Write (GPIOnum, State)
	Parameters	GPIOnum = Number of GPIO output pin to set the state of. (UDINT) State = Desired output state (true or false) (BOOL)
	Return	none
EZ_LcdClear	Description	Clears the LCD Display.
	Format:	EZ_LcdClear ();
	Parameters	n/a
	Return	none
EZ_LcdInit	Description	Initializes the LCD Display.
	Format:	EZ_LcdInit();
	Parameters	n/a
	Return	none
EZ_LcdWrite	Description	Writes to (Displays data) on the LCD Display.
	Format:	EZ_LcdWrite (Row,Column,Data)

	Parameters	Row = Row of the LCD Display to Write data to 0 to numrows (DINT)
		Column = Starting Column of the LCD Display to Write data to (DINT)
		Data = string to transmit (data may be formated using **EZ_FormatString**)

	Return	none
EZ_ModbusMaster_UartEnable-Isr	Description	Controls Modbus communication enable.
	Format:	BOOLvar := EZ_ModbusMaser_UartEnableIsr(FD_x, status);

	Parameters	FD_x = File Descriptor
		Status = 0 or 1, True or False (BOOL)

	Return	If False, disables interrupt and disables Modbus read / write (functions won't work)
EZ_SpiWriteData	Description	Writes data to SPI port (device)
	Format:	DINTvar :=EZ_SpiWriteData (FD_x, flags, clkrate,GPIO, txbuff, rxbuff, len);
	Parameters	FD_x **=** File descriptor flags = 16#10000 for active low SPI clock, else uses high SPI Clock = 16#20000 to capture data on first clock transition. CPHA = 0, else CPHA gets set to 1. Low 8 bits are data fram size (4-16). Typical size is 8 bits. clkrate = clock rate in Khz, maximum 10 Mhz. (UDINT) GPIO = GPIO number for chip select of SPI device (UDINT) txbuff = Array for data transmit. (USINT) rxbuff = Array for data receive. (USINT) len = Number of frame transfer, sized based on data fram size (UDINT)
	Return	# of bytes transferred or negative value if error occurs
	Notes	On P-Series targets, minimum clock rate is 2KHz

Target Specific Function	Description / Details	
EZ_UartEnableIsr	Description	Controls UART enable.
	Format:	BOOLvar := EZ_UartEnableIsr(FD_x, status);

	Parameters	FD_x = File Descriptor
		Status = 0 or 1, True or False (BOOL)

	Return	If False, disables interrupt and disables UART read / write (functions won't work)
EZ_UartGetBytestoRead	Description	Gets the number of UART bytes available to read.
	Format:	DINTvar := EZ_UartGetBytesToRead (FD_x);
	Parameters	FD_x = File Descriptor
	Return	# of bytes avalible to read in the receive buffer.
EZ_UartIsTxFinished	Description	Identifies if UART is finished transmitting data.
	Format:	BOOLvar :=EZ_UartIsTxFinished(FD_x);
	Parameters	FD_x = File descriptor
	Return	True when transmit is complete, false when transmit has not completed
	Notes	If using RS485, this will turn off the RS485 tranmsitter after all of the characters have been transmitted.
EZ_UartRead	Description	Reads data from a UART (serial port)
	Format:	DINTvar :=EZ_UartRead(FD_x, rxbuff, offset, len);
	Parameters	FD_x = File descriptor rxbuff = Buffer to store received data (ARRAY[ ] of USINT) offset = Zero based offset into buffer to start writing data (DINT) len = Numbef of bytes to read (DINT)
	Return	# of bytes to read.
	Notes	This will read up to len bytes from the receive buffer. This function will not wait until len bytes have been received, so check the return value to see how many bytes have been read.
EZ_UartSetBaudRate	Description	Set the UART baud rate
	Format:	DINTvar := EZ_UarSetBaudRate(FD_UARTx, baudrate);

	Parameters	FD_UARTx = File Descriptor
		baudrate = Baud rate for Uart to use (ie: 19200, 9600) (UDINT)

	Return	0 when Baud rate set is successful.
EZ_UartWrite	Description	Writes data to a UART (serial port)
	Format:	DINTvar := EZ_UartWrite(FD_UART, txbuff, offset, len);
	Parameters	FD_UARTx = File Descriptor txbuff = Buffer to data to transmit (ARRAY[ ] of USINT) offset = Zero based offset into buffer to start reading transmit data (DINT) len = Numbef of bytes to write (DINT)
	Return	# of bytes written or 0 if busy.
	Notes	This will copy *len* bytes to the transmit buffer, start transmitting the data using an interrupt. This function will return before all of the data has been transmitted, so use EZ_UartIsTxFinished to see if the data has finished transmitting.

Target Specific Function	Description / Details	
EZ_UartWriteStr	Description	Writes a string to a UART (serial port)
	Format:	DINTvar :=EZ_UartWriteStr(FD_UART, strbuff) ;

	Parameters	FD_UARTx = File descriptor for Uart #
		strbuff = string to transmit

	Return	# of bytes written or 0 if busy.
	Notes	This will copy *len* bytes to the transmit buffer, start transmitting the data using an interrupt. This function will return before all of the data has been transmitted, so use EZ_UartIsTxFinished to see if the data has finished transmitting.

EZ LADDER Structured Text Editor

To create structured text funtions and functionblocks, EZ LADDER Toolkit has a built-in editor. To open the ST Editor, click the **EDIT ST FUNCTIONS** button located on the toolbar. Refer to Figure 26-17.

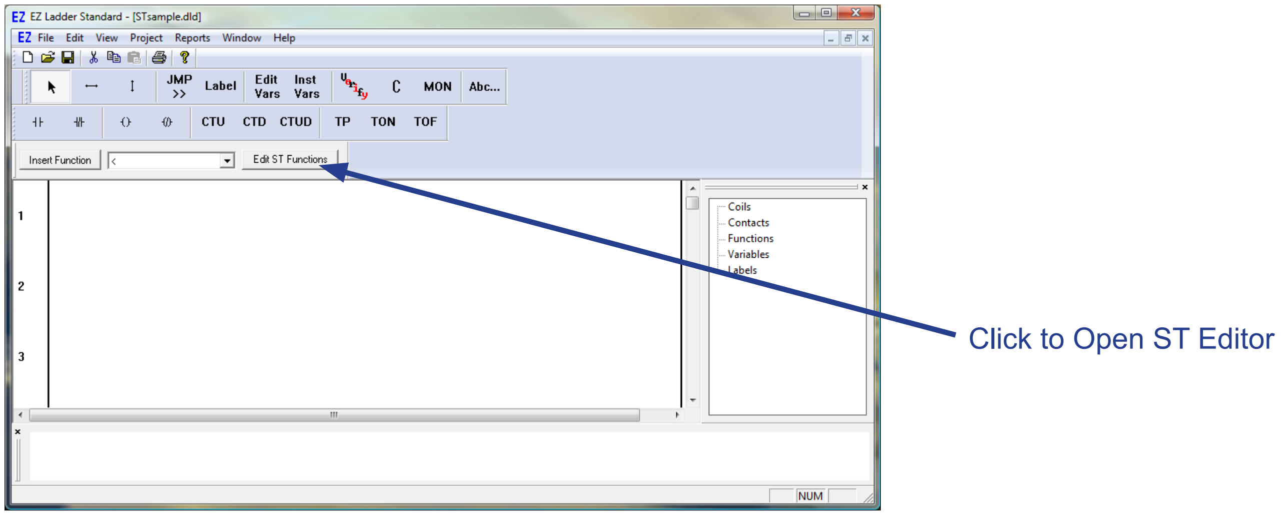
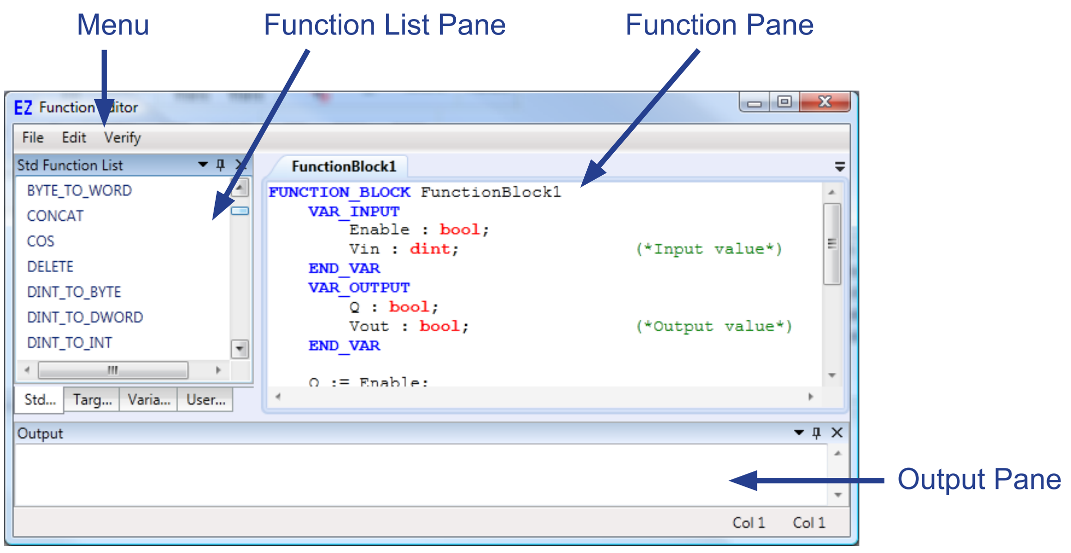


Figure 26-17

The ST Editor window (labeled Function Editor) will open It has it's own menu and is divided into three distinct sections: Function List Pane, Function Pane and Output Pane. Each pane has it's own purpose. Refer to Figure 26-18.



```
FUNCTION_BLOCK FunctionBlock1
    VAR_INPUT
        Enable : bool;
        Vin : dint;                 (*Input value*)
    END_VAR
    VAR_OUTPUT
        Q : bool;
        Vout : bool;                (*Output value*)
    END_VAR

    Q := Enable;
```

Figure 26-18

Function List Pane

The function list pane lists the functions and function blocks by type. Four tabs are located at the bottom of the pane. The first tab is for Standard functions such as ASIN and LIMIT. The second tab is for Target Specific functions as previously listed. Only the target specific functions listed in this tab are availabe to your selected hardware target. The third tab list the variables. The variables listed are the variable file descriptors for accessing specific target hardware (and ladder diagram variables) from structured text. The fourth tab is for User-Declarations functions. This tab will hold any functions or function blocks that you have created. Selecting the tab changes the contents for the pane. Figure 26-19 is a sample of each tab contents.

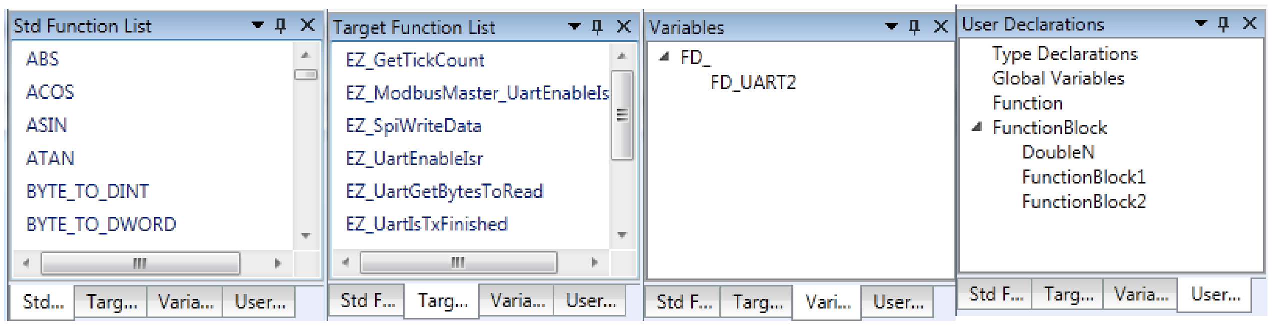


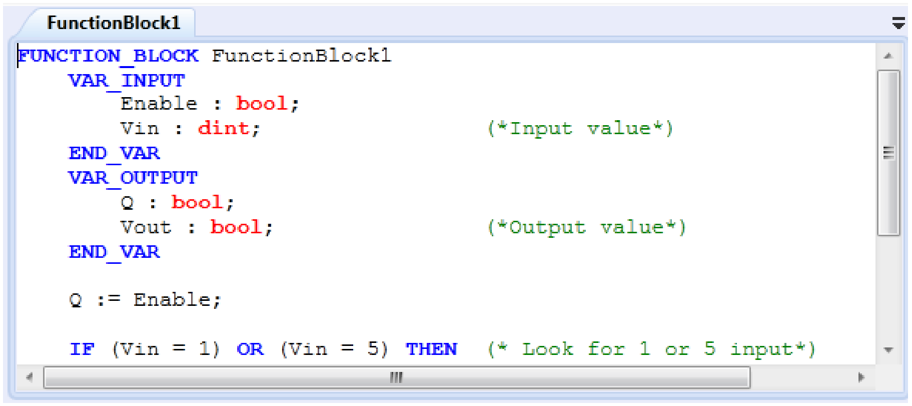
Figure 26-19

When creating and editing User-Defined functions, placing the cursor at a location in the function pane and then double-clicking a Standard function, Target Specific function or variable in the functions pane will place the item in your user-defined function.

In the User-Declaration tab, the user defined declarations, variables, functions and function blocks are sorted by type. Expanding the type will list any defined items. In Figure 26-19, the Function Block type is expanded showing three user-defined function blocks have been created.

Function Pane

The function pane is the area that user-defined functions and function blocks structured text code is edited. When a user-defined function is open, the window will act as a text editing window. The strutured text code is entered and manipulated as in any other text editor. Figure 26-20 is a sample of the function pane with an open function block.



```
FUNCTION_BLOCK FunctionBlock1
    VAR_INPUT
        Enable : bool;
        Vin : dint;                 (*Input value*)
    END_VAR
    VAR_OUTPUT
        Q : bool;
        Vout : bool;                (*Output value*)
    END_VAR

    Q := Enable;

    IF (Vin = 1) OR (Vin = 5) THEN  (* Look for 1 or 5 input*)
```

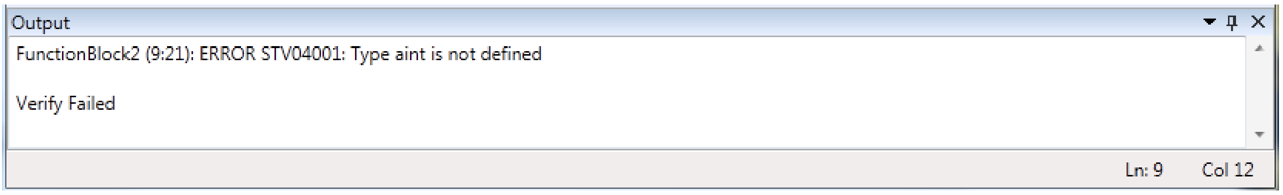
Figure 26-20

The function pane colors text based on what is detected. In Figure 26-20, contructs and statements are colored blue, variable types are colored red, comments are colored green and standard text is colored black. This coloring is automatic.

After a function has been changed in any way, is must be verified and saved before it may be used. See the *User-Defined Functions and Function blocks* section of this chapter.

Output Pane

The Output Pane is where important messages and status about the open structured text user-defined functions and function blocks are listed including when any function or function block is verified for proper syntax and content. Figure 26-21 is an example of a function block that has failed verification with an error. This error would need to be corrected before the function block can be used. Note, the location (line and column) are shown in the lower right hand corner identifiying the location where the error was detected.



```
FunctionBlock2 (9:21): ERROR STV04001: Type aint is not defined

Verify Failed
```

Figure 26-21

User-Defined Functions & Function Blocks

As previously discussed, custom structured text functionality is added using user-defined functions or function blocks. These functions (blocks) can be called from other ST functions (blocks) or from the ladder diagram. Restrictions apply depending how the user-defined function (block) is to be called. See earlier sections of this chapter.

Creating a New User-defined Function or Function Block

1. To create a new user-defiend function or function block, open the ST Editor using the **EDIT ST FUNCTIONS** button. The ST Editor will open.
2. Click the User-Declarations tab to view the user-defined items.
3. Single Click to highlight the FunctionBlock (or Function) heading in the User-Declarations tab.
4. Right click and select the ADD from the menu.
5. A new function block will be created and opened in the Function Pane. This function block will have all minimal requirements including the function block beginning and ending code required. This function block can be edited and added to as required.

To quickly add a standard function, Target-specific function or variable to the function (function block), place the cursor as the desired insertion point in the function (function block); click the appropriate tab and double-click the desired function to add. The item is added into the location selected in the user-defined function (function block).

The next step with your code added is to verify the user-defined function (function block). In the ST Editor window, click the **Verify** item from the menu. In the Output Pane, either an error message will be seen or the *Verify Passed* will be seen. If an error message is shown, the error must be corrected before proceeding. If the *Verify Passed* is shown, it is time to save the function (function block).

An unverified function or function block may be saved without verification but it will not be usable until it is verified and will not show in drop down menu to call the function or function block from the ladder diagram.

To save the user-defined function or function block, using the ST Editor menu, click the File...then Save option. The function or function block is now saved.

Editing an Existing User-defined Function or Function Block

1. To edit a new user-defiend function or function block, open the ST Editor using the **EDIT ST FUNCTIONS** button. The ST Editor will open.
2. Click the User-Declarations tab to view the user-defined items.
3. Single Click to expand the FunctionBlock (or Function) heading in the User-Declarations tab.
4. Double-click the desired function or function block to edit.
5. The function block (or function) will be opened in the Function Pane. This function can be edited by adding to or removing structured text as required.

To quickly add a standard function, Target-specific function or variable to the function (function block), place the cursor as the desired insertion point in the function (function block); click the appropriate tab and double-click the desired function to add. The item is added into the location selected in the user-defined function (function block).

The next step with your code added is to verify the user-defined function (function block). In the ST Editor window, click the **Verify** item from the menu. In the Output Pane, either an error message will be seen or the *Verify Passed* will be seen. If an error message is shown, the error must be corrected before proceeding. If the *Verify Passed* is shown, it is time to save the function (function block).

An unverified function or function block may be saved without verification but it will not be usable until it is verified and will not show in drop down menu to call the function or function block from the ladder diagram.

To save the user-defined function or function block, using the ST Editor menu, click the File...then Save option. The function or function block is now saved.

DIVELBISS
SOFTWARE LICENSE AGREEMENT

This Software License Agreement (the "Agreement") sets forth the terms by which Divelbiss Corporation, an Ohio corporation having a principal place of business at 9778 Mt. Gilead Road, Fredericktown, Ohio ("Divelbiss"), authorizes its bona fide licensees who have paid all applicable fees and accepted the terms of this Agreement (each a "Licensee") to use the Licensed Software (as defined below) provided herewith. Installing, using or attempting to install or use such Licensed Software or otherwise expressing assent to the terms herein constitutes acceptance of this Agreement. Any installation, use or attempted installation or use of such Licensed Software by any party other than a Licensee or otherwise in violation of this Agreement is expressly prohibited.

Introduction
Whereas Divelbiss has developed certain modules of computer software known as "PLC ON A CHIP Kernel" and "EZ LADDER Toolkit"; and Licensee wishes to secure certain rights to use such software ; and Divelbiss is prepared to license such rights, subject to the terms and conditions of this Agreement; therefore, in consideration of the mutual covenants contained herein and intending to be legally bound hereby, Divelbiss and Licensee agree as follows:

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The PLC ON A CHIP Kernel and EZ LADDER Toolkit software, whether in source code or object code format, and all related documentation and revisions, updates and modifications thereto (collectively, "Licensed Software"), is licensed by Divelbiss to Licensee strictly subject to the terms of this Agreement.

2. License Grant

Divelbiss hereby grants to Licensee a non exclusive, non-transferable license to use the Licensed Software as follows.

(a) Except as otherwise provided herein, one (1) user may install and use on one (1) desktop personal computer and on one (1) portable personal computer the EZ LADDER Toolkit (i) to develop, test, install, configure and distribute certain applications on certain hardware devices such as programmable logic controllers (each a "Resulting Product"), and (ii) to configure the PLC ON A CHIP Kernel on designated processors, which shall constitute Resulting Products.

(b) Licensee may copy the EZ LADDER Toolkit only for backup purposes.

(c) Licensee may not amend, modify, decompile, reverse engineer, copy (except as expressly authorized in Section 2 of this Agreement), install on a network, or permit use by more than a single user, in whole or in part, the Licensed Software, or sublicense, convey or purport to convey any such right to any third party.

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3. License Fee

(a) Except when Licensee obtains the EZ LADDER Toolkit from an approved distributor or OEM pursuant to other fee arrangements, Licensee will pay to Divelbiss the license fee for the EZ LADDER Toolkit specified in the applicable Divelbiss price list, which is due and payable upon delivery of same.

(b) If Licensee fails to make any payment when due, Divelbiss may, at its sole option, terminate Licensee's rights under this Agreement to use the Licensed Software. If Licensee fails to pay any balance within thirty (30) days after being notified by Divelbiss that payment is overdue, Divelbiss may take whatever steps it deems necessary to collect the balance, including referring the matter to an agency and/or suing for collection. All expenses and fees associated with the collection of an overdue balance, including costs and fees of collection and attorney's fees, shall be paid by Licensee. Overdue balances are subject to a monthly finance charge equal to the greater of [1.5]% or the maximum interest rate permitted by law times the unpaid balance.

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(a) Upon request of Divelbiss, Licensee will provide a written report each quarter showing the number of Resulting Products produced, distributed or sold by Licensee during the previous calendar quarter, the parties (identified by name, address, etc.) to which they were distributed or sold, and the revenue received therefor.

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(b) Divelbiss further warrants that for a period of 90 days from the date this Agreement is accepted by Licensee, the EZ LADDER Toolkit will perform substantially in accordance with the accompanying documentation provided by Divelbiss, provided that the EZ LADDER Toolkit (i) has not been modified, (ii) has been maintained according to all applicable maintenance recommendations, (iii) has not been used with hardware or software or installed or operated in a manner inconsistent with any manuals or relevant system requirements provided by Divelbiss, and (iv) has not been subjected to abuse, negligence or other improper treatment, including, without limitation, use outside the operating environment or range of applications prescribed in any manuals or relevant system requirements provided by Divelbiss by Divelbiss. Provided that Licensee gives prompt written notice to Divelbiss of any alleged breach of the foregoing warranty and that such alleged breach can be reproduced by Divelbiss, Divelbiss will use commercially reasonable efforts to repair or replace the EZ LADDER Toolkit so that it performs as warranted, or , at its sole option, refund to Licensee a prorated share of the license fee paid by Licensee for the portion of the EZ LADDER Toolkit which caused the alleged breach of warranty. Licensee acknowledges that the foregoing represents Divelbiss's sole obligation and Licensee's sole remedy for any alleged breach of warranty regardingthe EZ LADDER Toolkit.

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(c) Licensee shall be solely liable for all Resulting Products, any and all warranties on Resulting Products shall be made only by and on behalf of Licensee, and Licensee shall make NO representations or warranties on behalf of Divelbiss.

(d) For the term of this Agreement and any renewal thereof, and for one (1) year thereafter, Licensee will not solicit or hire any of Divelbiss's employees.

7. Limitation of Liability

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RISE TO SUCH LIABILITY, OR THE AMOUNT OF A SINGLE-USER LICENSE FEE FOR THE EZ LADDER TOOLKIT, WHICHEVER IS GREATER.

8. Indemnification

(a) Subject to the limitations of Section 7 of this Agreement, Divelbiss will indemnify Licensee from and against liability for any judgment finally awarded by a court of competent jurisdiction against Licensee based upon a claim that the EZ LADDER Toolkit infringes any current U.S. patent or copyright of a third party, provided that Divelbiss is promptly notified of any such threats, claims or proceedings, afforded the opportunity to intervene in any such proceeding and given sole control over the defense of such claim, including all negotiations of any prospective settlement or compromise, and that Licensee gives all cooperation and assistance requested by Divelbiss in connection with same; and provided further that the foregoing obligation of Divelbiss does not apply with respect to any Resulting Products or any hardware, software (including the Licensed Software) or components thereof (i) not supplied by Divelbiss, (ii) made or modified in whole or in part by Licensee or according to Licensee's specifications, (iii) otherwise modified after delivery, (iv) combined with other hardware, software, products or processes by Licensee (including in creating Resulting Products) where such claim could have been avoided absent such combination, (v) insofar as Licensee continues allegedly infringing activity after being notified thereof or informed of steps or modifications that would have avoided the alleged infringement, or (vi) used by Licensee in violation of the terms of this Agreement.

(b) Licensee will defend, indemnify and hold Divelbiss harmless from and against any and all losses, liabilities, judgments, damages and claims against Divelbiss obtained or asserted by any third party (including any allegation of infringement or violation of proprietary rights), and all related costs, including attorney fees, incurred by Divelbiss, arising or resulting from or related to i) Licensee's use, modification or adaptation of the Licensed Software, including to create any application or any Resulting Product, ii) the operation or performance, or Licensee's or any third party's use, of any Resulting Product, iii) any breach by Licensee of any representation or warranty made by Licensee related to the Licensed Software or any Resulting Product, or iv) any breach by Licensee of any of its obligations under this Agreement.

(c) In the event that any claim of infringement under Section 8(a) above is, or in Divelbiss's sole judgment is likely to be, substantiated, Divelbiss may, at its sole discretion, use commercially reasonable efforts to i) obtain a license from the third party for Licensee to continue using the allegedly infringing feature or aspect of the EZ LADDER Toolkit; ii) replace or modify the allegedly infringing feature or aspect of the EZ LADDER Toolkit to avoid such infringement; or iii) terminate this Agreement and the license hereunder and refund a prorated portion of the initial license fee paid by Licensee for the allegedly infringing feature or aspect of the EZ LADDER Toolkit .

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12. Term and Termination

(a) This Agreement shall remain in effect from the date it is accepted until terminated as provided below.

(b) Divelbiss may terminate this Agreement and all license rights hereunder upon the occurrence of any of the following:

(i) Licensee fails to cure any material breach of this Agreement within thirty (30) days after receiving notice of such breach;

(ii) Licensee becomes insolvent or unable to pay its debts, makes an assignment for the benefit of creditors, ceases to be a going concern, files for protection of the bankruptcy laws, becomes the subject of any involuntary proceeding under federal bankruptcy laws or has a receiver or trustee appointed to manage its assets;

(iii) Licensee consolidates or merges into or with any other entity or entities or sells or transfers all or substantially all of its assets; or

(iv) Following ninety (90) days written notice of termination to Licensee.

(c) Licensee may terminate this Agreement and all licenses hereunder in the event that Divelbiss fails to cure any material breach of this Agreement within thirty (30) days after receiving notice of such breach.

(d) Any fees or expenses payable by Licensee to Divelbiss shall not be reduced or otherwise affected by termination of this Agreement. In the event of termination of this Agreement for any reason, neither party shall be liable to the other on account of loss of prospective profits or anticipated sales, or on account of expenditures, inventories, investments, or commitments.

(e) Upon termination of this Agreement for any reason, Licensee will immediately return to Divelbiss or, upon instruction from Divelbiss, destroy all copies of the Licensed Software (including all code, documentation, manuals, etc.) and all Confidential Information in its possession, and will certify in writing to Divelbiss that it has done so.

(f) All provisions regarding ownership, confidentiality, proprietary rights, payment of fees and royalties, indemnification, disclaimers of warranty and limitations of liability will survive termination of this Agreement.

13. Assignment and Sublicensing

This Agreement, the license granted hereunder and the Licensed Software may not be assigned, sublicensed or otherwise transferred or conveyed by Licensee to any third party without the express, written consent of Divelbiss.

14. Dispute Resolution

(a) In the event of any dispute arising between the parties related to the subject matter of this Agreement, except regarding the payment of fees under Sections 3 or 15 of this Agreement or as provided in Subsection (b) below ("Dispute"), the parties agree to attempt to resolve such Dispute according to the procedures set forth below.

(i) In the event either Divelbiss or Licensee notifies the other party of a Dispute, representatives of each party with adequate authority to settle such Dispute will promptly engage in direct negotiations. If such representatives are unable to resolve such Dispute within ten (10) business days after commencing negotiations, or twenty (20) business days after the initial notice of Dispute, then either party may initiate mediation of the Dispute as provided in Subsection (a)(ii) below.

(ii) In the event either party initiates mediation of the Dispute (by sending a written notice of mediation to the other party), then the Dispute shall be subject to mediation in Mt. Vernon, Ohio before a single mediator (to be proposed, in the first instance, by the party initiating mediation) who will be reasonably familiar with the computer industry and mutually acceptable to the parties. The parties agree to participate in such mediation in good faith, through representatives with due authority to settle any such Dispute. If such representatives are unable to resolve such Dispute within twenty (20) business days after commencing mediation, then each party may pursue whatever further recourse it deems necessary to protect its rights under this Agreement.

(b) Licensee agrees that any violation of this Agreement related to the Licensed Software or Confidential Information, specifically including Divelbiss's proprietary rights therein, is likely to result in irreparable injury to Divelbiss. Accordingly, notwithstanding any other provision of this Agreement to the contrary, Licensee agrees that Divelbiss shall be entitled to all appropriate relief from any court of competent jurisdiction, whether in the form of injunctive relief and/or monetary damages, to protect its proprietary rights in the Licensed Software and Confidential Information.

15. Maintenance and Support

(a) In consideration of the payment of annual maintenance and support fees by or on behalf of Licensee (payable for the first year with the license fee, and thereafter annually at least thirty (30) days before the anniversary date of this Agreement),

Divelbiss will provide maintenance and support of the EZ LADDER Toolkit, in the form of (i) such periodic corrections, updates and revisions to the EZ LADDER Toolkit as Divelbiss, in its sole discretion, may from time to time elect to release, and (ii) responses to inquiries submitted by Licensee by email to Divelbiss at sales@divelbiss.com.

(b) The maintenance and support fee is specified in the applicable Divelbiss price list.

6. General

(a) This agreement constitutes the entire agreement between the parties relating to the Licensed Software and the subject matter hereof, supersedes all other proposals, quotes, understandings or agreements, whether written or oral, and cannot be modified except by a writing signed by both Licensee and Divelbiss.

(b) In the event of any conflict between the terms of this Agreement and any purchase order or similar documentation prepared by Licensee in connection with the transactions contemplated herein, this Agreement shall govern and take precedence, notwithstanding Divelbiss's failure to object to any conflicting provisions.

(c) Notwithstanding anything to the contrary herein, except for payment obligations under Sections 3 or 15, neither party shall be liable for any failure of performance beyond its reasonable control.

(d) Except as otherwise provided, this Agreement will be subject to and construed in accordance with the laws of the State of Ohio (U.S.A.) without regard to its conflict of laws provisions. Exclusive venue for any legal action between the Parties arising out of or related to this Agreement or the subject matter hereof will be in the state or federal courts located or having jurisdiction in Knox County, Ohio (U.S.A.), which the Parties expressly acknowledge to have personal jurisdiction over them. The 1980 UN Convention on the International Sale of Goods (CISG) will not apply hereto.

(e) No waiver by either party of a breach of this Agreement shall operate or be construed as a waiver of any subsequent breach.

(f) The invalidity, illegality or unenforceability of any provision of this Agreement shall not affect the remainder of the Agreement, and this Agreement shall be construed and reformed without such provision, provided that the ability of neither party to obtain substantially the bargained for performance of the other shall have thereby been impaired.

(g) All notices, consents and other communications between the parties shall be in writing and shall be sent by (i) first class mail, certified or registered, return receipt requested, postage prepaid, (ii) electronic facsimile transmission, (iii) overnight courier service, (iv) telegram or telex or (v) messenger, to the respective addresses that the parties may provide.

(h) Licensee shall be deemed an independent contractor hereunder, and as such, shall not be deemed, nor hold itself out to be, an agent or employee of Divelbiss. Under no circumstances shall any of the employees of a party hereto be deemed to be employees of the other party for any purpose. This Agreement shall not be construed as authority for either party to act for the other party in any agency or other capacity, or to make commitments of any kind for the account of or on behalf of the other except to the extent and for the purposes provided herein.

(i) LICENSEE ACKNOWLEDGES THAT IT HAS READ THIS AGREEMENT, UNDERSTANDS IT, AND AGREES TO BE BOUND BY ITS TERMS AND CONDITIONS.